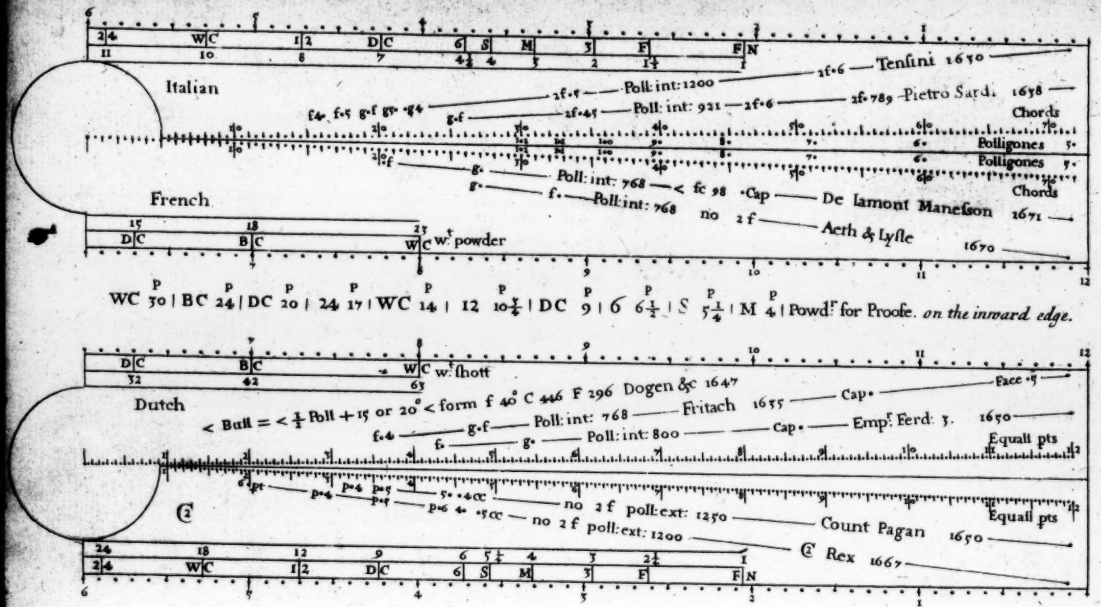
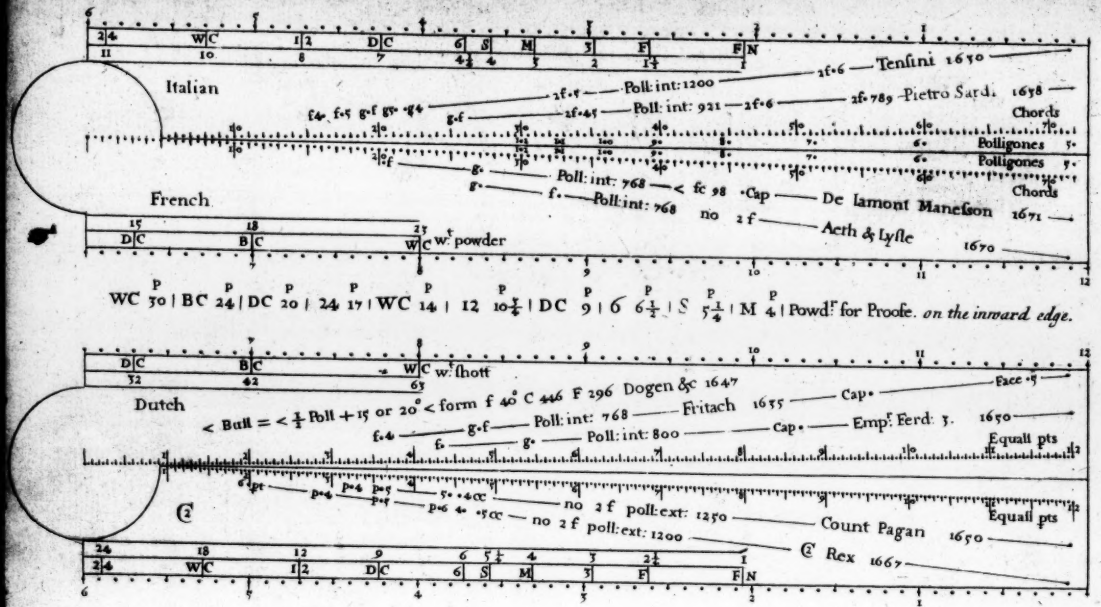


Mathematicall instruments made & sold in Silver Brass Ivory or Wood by John Marke at the Golden Ball in the Strand neare Sommersett house.



Mathematicall instruments made & sold in Silver Brass Ivory or Wood by John Marke at the Golden Ball in the Strand neare Sommersett house.

Modern Fortification:
OR,
ELEMENTS
OF,
Military Architecture.

Practised and Designed
By the Latest and most Experienced Ingeneers of this last Age, *Italian*, *French*, *Dutch*, and *English*.

And the manner of Defending and Besieging *FORTS* and *PLACES*.

With the use of a *Joynt-Ruler* or *Sector*, for the speedy Description of any *Fortification*.

BY
Sir *JONAS MOORE*, Master Surveyor of His MAJESTIES Ordnance.

LONDON,
Printed by *W. Godbid*, for *Nathaniel Brooke*, at the *Angel* in *Cornhill*. 1673.

TO THE RIGHT HONOURABLE

Sr. THO. CHICHELEY Kt:
Maſter-General of the Ordnance, and Armory, and one of His MAJESTIES *moſt Honourable Privy Council.*

Right Honourable,

I Ask your Pardon for prefixing to this little Book your great Name; Great in it ſelf, Great in the Honourable Charge you bear of *Grand Maſter of the Artillery.* You have been the Author's *Patron*, and

you are like to protect His, as well as Himself, for they will all be *Yours*. This TREATISE tells you of the *Modern Fortifications* used here, and in all Neighbouring Countries, and gives most easie Rules for their Description, indeed too Mechanical, it being calculated for the meanest understandings. If this Nation ever receive Damage by another, it will be for want of Knowledge and practice of Military Discipline, and Arts, there being few Soldiers of note in the *French* Army

Army, but underſtand their buſineſs, and the Terms of *Fortifications* and *Gunnery*, and can diſcourſe of Attaquing and Defending Towns *A la mode.*

The *old Engliſh* Valour is ſtill the ſame. And I could heartily wiſh the Gentry of *England* (taking Example from your *Honour*) were more inclinable to breed their Sons to Military Employment, and fit them to be Inſtruments for the ſafety and glory of their *King* and *Countrey.* I thought it now fit time to collect theſe Precepts,

cepts, moſt whereof were formerly writ for my *Son*'s Inſtructions, and now publiſhed for the Ends aforeſaid; and have given plain Rules for the caſting up the Floors, and carrying on the work, for making any new, or mending any old Fortification.

I have been and am preparing a large and coſtly Piece for your *Honours* view, of all the forms of Fortifications, and Models of all ſorts of Engines of War, of what nature ſoever, in fair Prints, that have

have been made or invented to this day, to the end that His *Majesty*, Your Honour, and Officers of the Ordnance, may see what has been done, and all Ingenious persons that busy themselves about such Inventions for the good of their Countrey, may be prevented to do what has been formerly acted, and His *Majesty*, and your Honour freed from the importunities of Novel Pretenders, and thereby not onely reap great Quiet, but save much unnecessary Expence.

Be-

Beſides, Strangers that fill our Ears with Notions of *Fortifications*, ſhall finde they are overdone many Bars length by others, and ſhall deſiſt from invading the Provinces of thoſe able Artiſts already imployed. But this Work will require both conſiderable Aſſiſtance, and Time to finiſh it. Sir, it is great pleaſure to me that I have this occaſion publickly to acknowledge the many and great Obligations wherein I ſtand bound to your Honourable Favour, and openly

penly to profeſs that inward Gratitude, which (God willing) I ſhall endeavour to ſhew upon all occaſions. God keep you from all Misfortune here, and give you eternal Happineſs hereafter; ſo heartily prayeth

Your *Honours*

Devoted Servant

Tower *March* 27. 1673. JONAS MOORE.

A Table of the Contents of this Book.

CHAP. I.

Of certain Propoſitions needful to be known.

§. 1. *To draw a ſtreight Line on the Ground.* pag. 1

2. *To Erect Perpendiculars either on Paper or on the Ground.* 2

3. *To let fall Perpendiculars either on Paper or on the Ground.* 3

4. *To meaſure an Angle on either.* 3

5. *To lay down an Angle on either.* 4

6. *To draw parallel lines on either.* 5

7. *To divide a Line into any parts.* 5

8. *To take the Plat of any Town or Place.* 6

9. *Of Regular Figures, their Natures, and how to lay them down on Paper or the Ground.* 7

10. *Of*

The Contents.

§ 10. *Of Meaſures. The Engliſh Foot compared with Forreign Meaſures, and of plain and Diagonal Scales.* 9

11. *The Dimenſion of plain Superficies.* 15

12. *The Dimenſion of Solid Bodies.* 15

CHAP. II.

Of the moſt Modern Fortifications of Regular Figures.

§ 1. *Of Regular Fortifications.* 16

2. *The Terms and Angles relating to the Principal Ground-line of any Regular Fortifications.* 17

3. *General Rules or Maximes.* 19

4. *The Conſtruction of the principal or Ground-line of a Fort.* 21

- 1. *After the* Italian *way.* 21
- 2. *After the* French *way.* 24
- 3. *After the* Dutch. 27
- 4. *After Count* Pagan, *and his Majeſties Alteration.* 32

5. *Of laying down upon the ground any of the former Fortifications, either with Inſtrument or without.* 38

CHAP.

CHAP. III.

The use of a Joynt-Rule or Sector, for describing Fortifications, and for Gunnery.

§ 1. *The Description of the Lines.* 41
2. *Of the Uses of the Joynt-Rule.* 47
1. *Of the Line of equal parts.* 47
2. *Of the Line of Chords.* 48
3. *Of the Line of Polygons.* 49
4. *Of the Lines of Fortifications.* 50
5. *Of the use of the Line of Inches.* 55
6. *Of the Lines for Guns, and weights of Shot & Powder.* 55

CHAP. IV.

Of the Rampire, Parapets, Tenails, Ditch, and Covert-way.

§ 1. *Of the Rampire.* 57
2. *Of the Dimensions and Measures of Rampires, Parapets, Ditch, Covert-way*

vert-way, and Breſt-work. 60

§ 3. *Rules to caſt up the Solidity of the Rampire, Parapet, together with the Parapet of the Covert-way, and to proportion the Wideneſs and Depth of the Mote.* 65

4. *How to build up any Fort, and how to make an Eſtimate of the Coſts and Money that will be required to do the ſame.* 74

5. *To know how long a Work will be in finiſhing, how many men muſt work to do it in the time preſcribed, and the Manner to be obſerved in working.* 79

6. *Works uſually made within the Forts, as Platforms, Cavaleers, Caſemats; And Works out of the Fort, as Ravelins, Horn, and Crown-works, and the like.* 80

CHAP. V.

Of Irregular Fortifications. 89

CHAP. VI.

Of the Defence of a Fort. 96

CHAP.

CHAP. VII.

Of Beſieging Places. 102

CHAP. VIII.

Of the way and manner how to Beſiege, Attaque, and Defend a fortified Town or Place, tranſlated out of French. 108

A Table of Angles. 120

MODERN FORTIFICATION.

CHAP. I.

Certain Propoſitions needful to be known.

¶ 1. *To draw a ſtreight Line upon the Ground from* a *to* b.

IF the Length of the Chord will reach both Marks *a* and *b* faſtening one end to *a*, ſtrain the Chord to *b*, and make a Lock-ſpit or Trench with a ſharp Spade; but if it be longer, then ſtrain the Line towards *b*, one holding a Stake or Picquet ſo upright at *c*, and moving of it to and fro, 'till at laſt *a*, *c*, and *b* may hide one another, and ſo one Length after another 'till you come at *b*. But if any Hill or riſing Ground be betwixt *a* and *b*, then muſt there be two Picquetts held at *c* and *d*, ſo that from *d*, *c* ſhall cover *a*, and from *c*, *d* ſhall cover *b*. And note, that in directing one another no

Fig. 1.

Fig. 2.

Fig. 3.

CHAP. VII.

Of Beſieging Places. 102

CHAP. VIII.

Of the way and manner how to Beſiege, Attaque, and Defend a fortified Town or Place, tranſlated out of French. 108

A Table of Angles. 120

MODERN FORTIFICATION.

CHAP. I.

Certain Propoſitions needful to be known.

§ 1. *To draw a ſtreight Line upon the Ground from* a *to* b.

IF the Length of the Chord will reach both Marks *a* and *b* faſtening one end to *a*, ſtrain the Chord to *b*, and make a Lock-ſpit or Trench with a ſharp Spade; but if it be longer, then ſtrain the Line towards *b*, one holding a Stake or Picquet ſo upright at *c*, and moving of it to and fro, 'till at laſt *a*, *c*, and *b* may hide one another, and ſo one Length after another 'till you come at *b*. But if any Hill or riſing Ground be betwixt *a* and *b*, then muſt there be two Picquetts held at *c* and *d*, ſo that from *d*, *c* ſhall cover *a*, and from *c*, *d* ſhall cover *b*. And note, that in directing one another no Fig. 1. Fig. 2. Fig. 3.

Words must be used, but onely Signs of the Hand.

§. 2. *To erect Perpendiculars, either on Paper, or upon the Ground, from any Line given.*

Fig. 4. First on Paper, from the point *a* take equal distances *a b*. *a c*. upon the Compasses to above half the Line, and from *b* and *c* strike Arches crossing at *d*; *d a* is a perpendicular: or upon the end of the Line *a* open the Compasses, and setting one foot in *a*, rest the other at *b*, and cross the line with that opening at *d*, and make an
Fig. 5. Arch at *c*, lay a Ruler by *b* and *d*, and cross the Arch at *c*. *c a* is a perpendicular.

Secondly, upon the Ground, it may be done by a large Carpenter's Rule or Level; or after the former manner, taking with your Line equal
Fig. 4. distances to *b* and *c*, and then by other equal distances to *d*. Or it may most easily be done by a *Quadrant* or other Instrument, setting the Sights upon the beginning of the Instrument; look upon the straight line given, and then turning the Sights to 90 degrees let some set a Picquet forwards in that line which will be perpendicular. Or lastly, by the Foot-chain set off
Fig. 6. 40 Foot from the point *a* to *b*, and taking 50 Foot in one Chain from *b*, and 30 foot from a cross them at *c*, *c a* is a perpendicular, for 5. 4. 3. describes a right angled Triangle.

§. 3:

§ 3. *From any point above a Line to let fall a Perpendicular either upon the Paper or the Ground.*

At *a* either with the Compaſſes, or with a Line or Chord croſs the Line given at *b* and *c*, divide the diſtance *b c* into 2 equal parts in *d*, *a d* is a perpendicular.

§. 4. *To meaſure an Angle either on Paper, or on the Ground.*

Every Angle is meaſured by that part of a Circle deſcribed on the angular point, intercepted betwixt the Lines of the Angle. Every Circle, whether great or ſmall, is divided or conceived to be divided into 360 degrees. Every Degree into 60 Minuts: a Quadrant into 90°. Therefore, if the Angle, for Example, be 30°, it will be ſo from a Circle of 1. 10. or 100 foot Radius. You muſt have a Circle ſo divided, or a Semicircle called a *Protractor*, or a Line of Chords which has the degrees projected on a ſtraight Line; by any of which you may meaſure an Angle as followeth.

Let the Angle on Paper be *b a c*, place your Protractor or Circle ſo on *a*, that the beginning thereof may lye on *a b*, the degrees intercepted by *a c* is the Angle, and is here 42°. But by a Line of Chords, you muſt take 60° degrees from it, and deſcribe an Arch *b c*, take Fig. 7.

b c with your Compasses, and that distance applyed to your Scale will shew 42°.

Fig. 8. Upon the Ground place your Circular Instrument or Quadrant over the Point *a*, and turning your Sights to the Picquett *b*, with the beginning of your Instrument fix it there, then turning your Sights to the Picquet *c*, you will find intercepted 42°. If you use a Quadrant, and the Angle be above 90°. then turn the Edge of your Quadrant to you, and the Sights turned to the other mark, will shew the degrees of the Angle.

Fig. 8. But if you have no Instrument by you, measure out 30 Foot on either Line to *b* and *c* from the Angle *a*, and find the Length from *b* to *c*, which Length look in the Table of Angles, and it gives you the Angle; suppose it was 21 Foot, 6 Inches, the Angle will be found 42°.

§ 5. *To lay down any Angle given either on Paper or the Ground.*

This is but the back way of the former, and is done by placing the Circle, Circumferentor, or Instrument, on the point of the Line given *a b*, and marking the Picquett, there make your mark, and draw out the Angle given.

§ 6.

§ 6. *To draw a Parallel-Line to any other Line given at any diſtance required, either on Paper, or the Ground.*

Firſt on Paper. Suppoſe it be required to make a Parallel to *a b* at *c*; ſet your Compaſſes in *c*, and take the neareſt diſtance to the Line *a b*, with which, ſetting one point in any convenient part of the Line *a b*, deſcribe part of an Arch at *d*, *c d* will be parallel to *a b*. Fig. 9.

Upon the Ground, take the neareſt diſtance from *c* to *a b*, and at a convenient diſtance raiſe a Perpendicular on the Ground to *a b*, as *b d*, meaſure the ſame diſtance of *a c*, and ſet it off from *b* to *d*, by *c* and *d* draw a Line which ſhall be parallel to *a b*. Fig. 10.

§ 7. *To divide a Line given either on Paper or on the Ground, into any number of equal or unequal Parts, or like to any other Divided Line.*

Firſt on Paper. The Line *a b* is given to be divided into 5 Parts, as the Line *c d*, which is taken at liberty, and was firſt cut into 5 Parts; upon the Point *c* draw out a Line, making an Angle with *c d*, make *c f* equal to *a b*, joyn the extremities *f* and *d*, and draw parallel Lines through the 4 Points of *c d*, which ſhall divide Fig. 11.

a b in 5 equal Parts: This way is to be uſed when the Line given is longer then the divided Line.

But if *a b* be ſhorter then the Line *c d* divided, then take *a b* in your Compaſſes, and make
Fig. 12. an Arch above *d* at *f*, and from *c* draw a Tangent, *c f*: The neareſt diſtance of the Diviſions *c d* to that Tangent are the Diviſions of *a b*, as you may ſee in the Figure. Theſe two ways grounded upon the ſecond Propoſition of the Sixth of *Euclide*, well underſtood, demonſtrates the Operations of the Sector or Joynt Rule, and many other uſeful Propoſitions. But to divide a Line upon the Ground, meaſure it exactly into Feet and Inches, and divide it by the number of Parts you would cut it into, then meaſure out the Parts by the Chain or Line accordingly.

§ 8. *To take the Platt or Plant of any Town or parcel of Ground deſired.*

Practice over-does any Directions can be given; let the Scholar begin with any cloſe or ſmall parcel of Ground: Suppoſe *a b c* be a ſpot of Ground to be laid down, having with you any Inſtrument to take Angles, or by the
Fig. 13. Chain, as in *Prop.* 4. beginning at *a*, take the Angle *c a b*, which you will find to be 64 degrees, then meaſure with your Chain from *a* to *b*, which

which may be 912 Feet, which ſet down in your Note; then proceed, and by your Inſtrument at *b* take the Angle *a b c*, which you will find to be 40 degrees, and meaſure *b c* 845 Feet, and the Angle *b c a* 76 degrees, and *c a* 604 Feet. Having done this upon Paper to deſcribe and delineate this Platt draw *d e* at length, upon *d* deſcribe the Angle of 64 degrees, and draw *d f*, this Angle repreſents the Angle *a* upon the Ground, by any convenient Scale of equal parts take with your Compaſſes 912 and ſet it from *d* to *e*, at *e* ſet off an Angle of 40 degrees, and draw *e f*, ſo doth the Figure *d e f* repreſent *a b c*, and by the ſame Scale you made uſe of you will find *e f* 845 and *f d* 604. Fig. 14.

After go to harder Platts, all the whole conſiſting in the Angles and Meaſure of the Sides, which being carefully laid down will perform what is deſired; imitating and laying down on Paper the Turns and Crooks of the Ground as well as poſſibly may be.

§. 9. *Of the Regular Figures, their Natures, and how by any Side given to lay them down on Paper or on the Ground.*

Regular Figures are the Triangle, Square, Pentagon, Hexagon, Heptagon, *&c.* Divide 360° by the number of the Sides propoſed, the Quotient is the Angle at the Center, the Com-

plement whereof to 180° is the Angle at the Figure, and half of that is the Angle of the Triangle at the Figure, as you may see in the Pentagon.

	Regular Figures.	*Angles at the Center.*	*Angles at the Figure.*	$\frac{1}{2}$
Sides	3	120	60	30
	4	90	90	45
	5	72	108	54
	6	60	120	60
	7	51-43½	128-34½	64-17¼
	8	45	135	67½
	9	40	140	70
	10	36	144	72

Now any Side or Line being given, if with a Protractor or Line of Chords you set off the Angle at the Figure, and work so many times as your Figure has Sides, you may, if exactly done, enclose the Figure: Or by setting off at both the Ends of the Line given the Angle of the Triangle (which is always half the Angle at the Figure) and protract two Lines; Their meeting will shew the Center of the Circle wherein the Side given may be inscribed. Or, Lastly, laying down the Angle of the Center of the Figure proposed, with the Compasses take such a distance from the Center of the Figure, equally on both Sides of the Angle, as may make that third Side near equal to the Side proposed; divide that third Side equally, and draw a Line through it from the Center

Fig. 15.

Center, fit each half of the Line given upon the third Line, if it exceed or be ſhort, by Parallels on each end cut the Sides of the Angles, thoſe Interſections will find the place where to fit the Line propos'd. All which ways you will find practiſed in the 15*th* Figure, as to the Angles; and the ſame practice will do it upon the Ground.

§. 10. *Of* MEASURES. *The* Engliſh *Foot compared with the famous Meaſures of other places; and of plain and Diagonal Scales.*

To underſtand as near as poſſibly might be the length of each Foot of ſeveral Countries, I have taken great pains to reconcile the differences found in the Tables of *Snellius*, *Dogen*, Mr. *Greaves*, *Caſimirus*, and *Ricciolus* in his *Geography*; and have procured ſeveral lengths from inquiſitive Perſons; I have moiſtened the Prints, and tried above 60 ſeveral Papers of the length of Feet, and give you the following Table for the neareſt, wherein the *Engliſh* Foot is ſuppoſed to be divided into 1000 parts, and the proportion to that is ſet down againſt the Places that each Countries Foot bears to 1000. In the next Column is expreſt the proportion in Feet, Inches and Tenth Parts: And the laſt Column is the proportion that each Pound at the ſeveral Places bears to the *Engliſh* Pound *Avoirdupois* divided into 100.

A Table containing the Proportion that the Engliſh Foot, divided into 1000 *parts, or into* 12 *Inches and Tenths, beareth to the Meaſures of other Countreys, and the proportion of a Pound weight Averdupois divided into* 100 *parts, beareth to the Forraign Pounds.*

France.	*English Foot into* 1000	*Engl. Feet Inch. & Tenths.*	*lb Aver. into* 100.
Paris, the Royal Foot—	1:068	1. 0:8	.93
Lyons, the Ell there—	3:976	3.11.7	1.09
Bologn, the Ell —	2:076	2. 0:8	8.9
The 17 Provinces.			
Amſterdam Foot—	:942	0.11:3	.93
Ell—	2.269	2.03:2	
Antwerp Foot—	.946	0.11:3	.98
Ell—	2.273	2.03:3	
Brill, the Foot—	1.103	1.01:2	
Dort, the Foot—	1.184	1.02:2	
Rindland or *Leyden* foot	1.033	1.00:4	.96
Ell	2.260	2.03:1	
Lovain Foot—	.958	0.11:4	.98
Mecklin Foot—	.919	0.11:0	.98
Middleburg Foot—	.991	0.11:9	.98

Ger-

Germany.	E. Foot into 1000	E. feet, Inches & T.	Av. poss. into 100.
Strasbrough Foot	.920	0.11:0	.93
Bremen Foot	.964	0.11:6	.94
Cologn Foot	.954	0.11:4	.97
Franckford on the *Main* Foot	.948	.11:4	.93
Ell	1.826	1.099	
Hambrough Ell	1.905	1.10:8	.95
Leipsig Ell	2.260	2.03:1	1.17
Lubeck Ell	1.903	1.09:8	
Noremburg Foot	1.006	1.00:1	.94
Ell	2.277	2.03:3	
Bavaria	.954	0.11:4	
Vienna	1.053	1.00:6	.83
Spain & Portugal.			
Spanish Palm, or the Palm of *Castile.*	.751	0.09:0	.99
The *Spanish* Vare, or Rod, being 4 Palms	3.004	3.00:0	
The Foot is one $\frac{1}{3}$ of the Vare.	1.001	1.00:0	
Lisbon, the Vare	2.750	2.09.0	1.06
Vare at *Gibralter*	2.760	2.09:1	1.03
The *Toledo* Foot	.899	0.10:7	1.00
Vare	2.685	2.08:2	
Italy.			
Roman Foot on the Monum. of *Cossutius*	.967	0.11:6	1.23

	E. foot into 1000.	E. Feet Inches & T	Lib. Acer. into 100.
Of *Stadius*	.972	0.11:7	
Roman Palm for Building, whereof 10 makes the Cauna	.732	0.08:8	
Bononia Foot	1.204	1.02:4	1.27
Ell	2.147	2.01:7	
Pearch, whereof 500 to a Mile	12.040	12.0:5	
Florence Brace, or Ell	1.913	1.11:0	1.23
Naples Palm	.861	0.09:6	1.43
Brace	2.100	2.01:2	
Cauna	6.880	6.10:5	
Genua Palm	.830	.09:6	1.42
Mantua Foot	1.569	1.06:8	1.43
Millan Calamus	6.544	6.06:5	1.40
Parma Cubit	1.866	1.10:4	1.43
Venice Foot	1.153	1.01:9	1.53
Other Places.			
Dantsig Foot	.944	0.11:3	1.19
Ell	1.903	1.10:8	
Copenhagen Foot	.965	.11:6	.94
Prage in *Bohemia* the Foot	1.026	1.00:3	1.06
Riga the Foot	1.831	1.09:9	
China the Cubit	1.016	1.00:2	
Turin the Foot	1.062	1.00:7	
Cairo the Cubit	1.824	1.09:9	1.61

The

	Engl. Foot into 1000	E. feet into In. & T.	Lib. A. into 100.
The *Persian* Arach--	3.197	3.02:3	
Turkish Pike at *Constantinople* the Great	2.200	2.02:4	.86
The *Greek* foot-	1.007	1.00:1	
Mouton's Universal foot, or a Pendulum that will vibrate 132 times in a Minute	0.675	0.08:1	

The Measures most made use of in Fortification, are the *Parisian*, *Rineland*, and *Venetian* Feet, which out of the Tables with their Multiplees to 9 are as followeth.

Parisian.	*Rineland.*	*Venetian.*
1. 1068.	1. 1033.	1. 1152.
2. 2136.	2. 2066.	2. 2304.
3. 3204.	3. 3099.	3. 3456.
4. 4273.	4. 4133.	4. 4608.
5. 5340.	5. 5166.	5. 5760.
6. 6408.	6. 6199.	6. 6912.
7. 7477.	7. 7233.	7. 8064.
8. 8546.	8. 8266.	8. 9216.
9. 9613.	9. 9299.	9.10368.

The Use of these Tables are plain. Suppose 800 *Venetian* Feet were proposed to be turned into English Feet, against 8 I find 9.2, and against

gainſt 80. 92.1, and againſt 800, 921.6 Engliſh Feet: ſo that 800 *Venetian* Feet make *Engliſh* 921 and a half: and 985 *Rineland* feet make 1017½ *Engliſh*.

906-929.9
80-82.6
5-5.1
1017.6

The *French* Accompt by the Toiſe or Fathom, which is ſix of their Feet for a meaſure in Fortification; the *Dutch* by the Rodd, which is 12 of their Feet; and we in *England* generally by a Rodd of 16 Feet and a half, which is not ſo good as to meaſure by the Rodd of Ten Foot, then 720 Feet is 72 Rodds. The *Venetian* account by the Pace, 5 Feet to a Pace, all which is of abſolute uſe for the comparing Foraign Meaſures with ours.

The next thing obſervable are Scales fitted for Meaſure, and are had upon every Ruler, ſuch as are the Scales in Figure 15th, are called Plain Scales, any part of a Line divided into Ten parts, and one of theſe parts again divided into 10 ſmall parts, and ſo numbred into 10.20. 30.40.50. 60. 70. 80. 90. 100. as you ſee by theſe Scales. But the moſt exact is the Diagonal Scale, Figure 16, of the ſame length with the third plain Scale; but that in this, thoſe little Diviſions are again divided into 10 parts by the Diagonals; the form thereof you may conſider in the Figures.

§. 11.

§ 11. *The Dimenſion of a plain Superficies.*

For a Square multiply the ſide by it ſelf. For an Oblong multiply the Longer by the Shorter ſide. For a Triangle, multiply any ſide by the Perpendicular falling on that ſide, (prolonged if need be) and take half the Product for the Superficies, or multiply the ſide by half the Perpendicular, or half the ſide by the whole Perpendicular. The Product gives you the Superficies in Rodds, in Fathoms, in Perches or Feet, as your Meaſures be.

But if your Figure be of many ſides, divide it into Triangles, and take the Content by adding all the Triangles together.

§ 12. *The Dimenſion of Solid Bodies.*

The moſt that is aimed at here, is the meaſuring of Foſſes or Moats, of Ramperts, Parapets, and other works of Fortifications, which ſhall be ſhewed more fully hereafter.

All ſuch Bodies as have no Tapering part, but are alike in their whole length, and ſuch are moſt of the aboveſaid Works, are meaſured after the faſhion of Parallepididon: get therefore the Superficies of the end, by ſome of the Rules in the laſt Propoſition, and multiply that by the length, the laſt Product gives you the Solidity.

These 12 Propositions are as much as may serve for ordinary Practice in Fortificattons, but an able Artist will not be content therewith, but will furnish himself with the knowledg of Geometry, and the Doctrine of Triangles, and all other curious Learning in this kind.

CHAP. II.

Of the most modern Fortifications of Regular Figures used in Italy France, Dutch-land, *and in* England.

§. 1. *Of Regular Fortifications.*

THey are called Regular, because made upon some one of the equal sided Figures mentioned Chap. 1. par. 9. viz. upon a Square, Pentagon or five-sided Figure, or upon 6. 7. 8. 9. &c. sided Figures.

The principal and onely Line to be regarded in all Fortifications, whether regular or irregular, is the outward or exteriour Line bounding the Rampart at the foot next the Ditch, from which Basis all the rest of the Lines depend, we will first give you the Terms and Angles of that Line, and then the Description thereof after the most modern way used abroad.

Sect. 2.

§. 2. *The Termes and Angles relalating to the Principal Ground-line of any regular Fortification, and first of the* Lines.

1. The *Interior Polygon* is the ſide of any Regular Figure, as in the Example of an Hexagon or ſix-ſided Figure (which I make uſe of through this Tract) any one of the ſix Sides is called the ſide of the Polygon, as here the line contained betwixt *p* and *p*, is the Interior Polygon, as the line *aa* is called the Exterior Polygon. Fig. 20.

2. The *Baſtion* or *Bulwork*, is that great work of any Fort that advanceth towards the Campaigne, being as a Caſtle for the Fort, and here are Six all marked with B. The Lines terminating the ſame are two Demigorges, two Flanks, two Faces.

3. The *Demigorge* or Gorge-line *p c*, being half of the entrance into the Baſtion, and terminates the Points *c*, whereby the Flank ſhall be raiſed.

4. The *Flank c f* is another out-line of the Baſtion terminating the Currain and Face. Fig. 20.

5. The *Face f a* is the foremoſt part of the Baſtion, two Lines thereof meeting in *a* the outward Point of the Baſtion.

6. The *Line forming the Flank* is *p f*, being a prick'd Line, made uſe of by *Dogen*, and the reſt of the *Dutch* Ingineers.

7. The *Capital Line* is *p a*, part of the Line coming from the the Center *O*, and terminated at the point of the Bastion *a*.

8. The *Curtain c c* is that part of the Interior Polygon, that lyes betwixt the two Bastions *B.B.*

9. The Lines passing from *a* the point of the Bastion, to *c* the point of the Flank and Curtain, is called the *Line of Defence fixed*, and ought never to exceed 800 English Feet, but rather to be less, because the length of the Port of a Musket doth not much exceed that Measure.

10. The Line coming from the Point of the Bastion *a*, and drawn upon the face *f a* to the Curtain *d*, is called the *Line stringent*, and shews how much of the Curtain *d c* will clear or scour the Face, which Line *d c* being part of the Curtain, is called the *second Flank*. Fig. 20.

11. The Line *O p*, coming from the Center *O*, is called the Diameter of the Interior Polygon.

12. *O m* the shortest Line from the Center to the Curtain.

The most Considerable angles are as followeth. The Angles are marked with 3 letters, the middle letter points out the Angle.

13. The *Angle at the Center* of the Polygon is *p o p*, and is gotten by Chap. 1. Sect. 9. Fig. 20.

14. The *Angle of the Polygon p p p*, or that which is equal to it *a a a*, is always the Complement

plement of the Angle at the Center or the Remainder of it to 180 degrees.

15. The *Angle of the Triangle o p p* or *oaa*, is half of the Angle of the Polygon.

16. The *Angle of the Baſtion f a f*, expoſed tothe Batteries of the Beſiegers, and made by the two Faces *fa. fa*, which ought not to be leſs than 60 degrees, or much above 90.

17. The *Angle of the Shoulder* or Eſpaule is made by the Face and Flank *a f c*.

18. The *Angle of the Flank* is made by the Curtain and Flank *f c c*, and by moſt Ingineers made to be a right Angle, but by ſome later (and may be not without cauſe) made obtuſe, or more than a right Angle. Fig. 20.

19. The Angles made by the two Lines fichant is called the *Angle of the Tenail a t a*.

20. The *Angle forming the Flank c p f* is made uſe of by the *Dutch* Ingineers.

§. 3. *General Rules or Maximes obſerv'd in Fortifications.*

1. All the parts of a Fort or place fortified ought to be flanked (that is) Defended from another part.

2. That the Baſtions that are not too little, nor yet too exceſſive big, are to be preferr'd before others.

3. That the Line of Defence, or that which is neer equal to it, viz. the Interior Polygon, be not longer than 800 feet, nor ſhorter than 500,

if it may be. But if it be resolved to furnish the Fort with many Cannon, then the Interior Polygon may be much longer, viz. to 1000 feet very well.

4. The greater and more spacious the *Gorges* and *Flanks* be, provided, the rest of the Work be not prejudiced thereby, the better is the Fortification.

5. The Angle of the *Bastion* may not be much less than 60 degrees, nor much more than 90; because in the first, the Point of the *Bastion* shall not be so slender as easily to be battered down, nor in the latter too obtuse or blunt to be opened at the Point.

6. The Angle of the *Flanks* may be more than 90 degrees, nor is there any virtue more in a right Angle for the better defence of a Fort than in an other.

7. The greater the Angle that is made by the outward Polygon and the Face shall be, the greater is the defence of the Face: and this last Maxime I hold to be so essential, that it shall try the goodness of all Inventions for what kind of Fortification soever.

§. 4. *The Conſtruction or making of the Principal Ground-line of a Fort according to the moſt Modern wayes uſed by the* Italian, French, Dutch, *or here in* England.

I. *Of the* ITALIAN *Fortifications.*

1. *Of* Seignior Tenſini. 1630.

In all Forts above the Pentagon, he makes the Gorge and Flank equal, and both a ſeventh part of the Interior Polygon, and the Face in all Figures whatſoever to be one third of the ſaid Interior Polygon.

He makes his Interior Polygon 217 *Venetian* Paces equal to 1250 *Engliſh* Feet, his Gorge and Flank, each 31 Paces, that is 178½ *Engliſh* Feet, and the Face 72 Paces and ¼, that is 416 *Engliſh* Feet. But for the Face always, and in all caſes 72¼ Paces, equal to 416½ *Engliſh* Feet. All which are very high Numbers, and not uſed, unleſs the Defence be made with many Cannon, *Tenſini* requiring to every Baſtion 30 Peeces, beſides what ſhall be planted on the Rampire.

For an Example in the Hexagon (which I make uſe of through this Tract) by Chap. 1. §. 9, upon any given Line taken for the Interior Polygon *p p*, I make an Hexagon *p p p p p p* &c. By Chap. 1. §. 7. I divide *p p* into 3 parts, and

7 parts. I take a Seventh part in my Compasses, and set it from *p* to *c* for the Gorge, and raising *c f* at right Angles, I set the same measure from *c* to *f*; lastly, I take one third part of *p p*, and setting one point of the Compasses in *f*, I cross the Capital Line at *a*, and draw *c f* and *f a*, which I do to every Bastion 'till all be complete.

In Numbers, supposing the Interior Polygon 1000, the Gorge and Flank will be each 143, and the Face 333, in all Figures above the Pentagon. In the Square the Gorge 161, the Flank 120. In the Pentagon the Gorge 156, the Flank 129.

Thus dividing *p p* into 1000, the Gorges, Flanks, and Faces will have the aforesaid Proportions, which may be wrought by any Scale divided into 100 or 1000 parts.

2. *Seignior Pietro Sardi.* 1638.

This worthy Author has writ much to good purpose, being learned and much experienced in the Wars of his time, he writ his Book of Architecture Military, intituled *Corona Imperiale*, Anno 1618; his Book of *Artillery*, 1621, an excellent Piece, and his Book of *Architecture* Military, intituled *Corona Regale*, 1638. He makes the *Interior Polygon* 800 *Venetian* Feet, (which is 921 of our English Feet,) his Gorge 150, and his Flank 150; that is, his Gorges and Flanks being equal, are betwixt a 5th and

6th

6th of his Polygon, which are greater and much better than the last of *Tensini's*. He determines the Faces of his Bastion by the line of Defence Raieing, he makes the Face continued to fall in the Square and Pentagon upon the tenth part of the Curtain, from the opposite Flanks; in the Hexagon on the fourth part, in the 7, 8 and 9, on the $\frac{1}{3}$ part, and in all above on the half.

Having drawn the Hexagon as before, and dividing the Interior Polygon *p p* into 800 parts, or first into 8, and then every of those into 10 again, take off 150 and prick it from *p* to *c* for the Gorges, and raising a Perpendicular at *c* set the same distances from *c* to *f* for the Flanks; then for to determine the Face, divide *c c* into 4 parts, and set one fourth from *c* to *d*, laying your Ruler upon *d* and *f* draw *f a* for the Faces. But if it had been a Heptagon, or 8gon, or 9gon, then *c d* had been a $\frac{1}{3}$ part of the Curtain *c c*, as before was expressed.

But supposing the Interior Polygon *p p* 1000, then 187 will be the proportion for the Gorges and Flanks, 250 (set from *p*) for the 2d Flank of the 4 and 5gon, 343 (set from *p*) for the Flank of the Hexagon, 395 for the 7, 8, 9gon, and 500 for all above.

3. *The third and last of the Modern Italian Authors, is one* Gennaro Maria, *Mathematician to the Catholick King, who writ* 1665 *at* Florence, *and dedicates his Book*

to the Grand Duke, intituled Breve Trattato delle Moderne Fortificazioni.

This Author makes the Interior Polygon 800 Feet, and not leſs than 600, his $\frac{1}{2}$ Gorge he makes $\frac{1}{8}$ part of it, and ſo for the Flank of the Quadrangle. But for the Pentagon, and all Figures above, he makes the Flanks, which ſtand at right Angles with the Curtain, one tenth of the Gorge more.

Suppoſing his Interior Polygon 1000, his Gorges will be 125, and the Flanks of the Quadrangle 125, but of the Pentagon and all above, 138. But this Author is not by me ſo well approv'd of, becauſe he makes his Gorges and Flanks too ſmall.

For the Faces, he makes them fall on the third part of the Curtain, excepting the Square that has no ſecond Flanks.

II. *Of the* French *Fortifications.*

1. *According to* De Ville *and* Furniers, 1647. *for Monſieur* Errard *is not approved.*

Divide the Interior Polygon into 6 parts, take one of thoſe parts for the Demigorge and Flanks, being both equal, and at right Angles.

Then for drawing the Faces of the 4th and 5th, lay a Ruler from the point of the Flank *c*, by *f*, draw *f a*, theſe have no ſecond Flanks.

For the Hexagon and all above, joyn *f f* by

a line, the Capital will divide it into two parts, at *k* make *ka* equal to *kf*, and draw *af* for the Face.

The Interior Polygon or Line of Defence, they make 150 Fathom, (which is equal to 960 Engliſh Feet.)

If the Interior Polygon be 1000, the Gorges and Flanks will be .166.

2. *According to Monſieur* De la Mont, *in his Fortification Offenſive and Defenſive printed* 1671. *and according to Monſieur* Maneſſon Mallet *in his late Work, intituled* Travaux de Mars, *Printed* 1672.

Both theſe Authors make the Interior Polygon *pp* 768 Engliſh Feet.

Both divide the Interior Polygon into 5 parts, and take one for the Gorges *pc*, that is 153½ Feet.

Both divide it into 3 parts, and take one for the Capital line *pa*, that is 256 Feet.

But *De la Mont* makes the Flank to ſtand at right Angles, and takes ¼ of the Curtain for its length *cf*, that is 115½ Feet, ſo draws the Baſtions in all except the Quadrangle and Pentagon, which he makes to have no ſecond Flanks.

And *Travaux de Mars* makes the Angle of the Flank and Curtain to be 98 degrees, and draws the Faces from the point of the Baſtion *a* to *c* the point of the Flank, leaving no ſecond Flanks in all his Fortifications. So

So that if the Interior Polygon be 1000, the Gorges will be 200, and the Capital 333.

In *De la Monts* the Flanks will be 150.

After these Proportions of *De la Mont*, there is a Triangular Scale made in *Paris*, and taught to young Gentlemen.

Fig. 24. For a General Rule for all Fortifications, see Figure 24, and observe in the Triangular *P p a*, *P p* is divided into 1000 Feet, and serves for the General Scale which you may enlarge and make as big as you please, *p a* stands at right Angles to *P p*. If you make *P p* 1000 Feet, as in this Example, then take 333 Feet for the Capital *p a*, 200 for the Gorge *p c*, and 150 for the Flank *p f*, as before was shewed to be *De la Mont's* Proportion, draw the lines *P a*, *P c*, *P f*, and likewise the Parallel lines to each 50 Feet, as in the Figure. The use of this Scale is thus; after you resolve how long your Inward Polygon shall be, which is represented by the Line *P p*, and may be taken of any length under 1000 Feet which you may not exceed, if it fall under 500 Feet it will be only fit for Cittadels and Field-works, as is marked in the figure. If it be above 500, and under 800, it is for Royal Forts and lesser Fortifications, such as may be defended by Musquet Shot. But if above 800 Feet, then such Forts must be well stored with great Guns. Where ever it falls,

Fig. 24. suppose your Inward Polygon be 700 Feet, marked *P p*, and in Figure 24 *p p*, take out of this Scale *p a* for the Capital, and prick it from

p

p to *a*-in all the Baſtions, take out *p c*, and ſet it off for all the Gorges, raiſe Perpendiculars at *c*, and take out *p f*, and ſet it from *c* to *f*, and draw the Faces *a f*, and finiſh your draught. Such other triangular Scales may be fitted for any other proportions in Fortifications.

3. *The King of* France *in the Fortifications made new at* Aeth *and* Lyſle.

His Ingineers have made the Interior Polygon not above 768 Engliſh Feet, has no ſecond Flank, the Gorges are the ſame with *Le Monts* and *Maneſſons*, that is $\frac{1}{5}$ of the Interior Polygon, or 200, the Interior Polygon being 1000, and the Flanks are made longer than the Gorge viz. 240, and ſtand at an Angle of 100 degrees from the Curtain.

III. *Of the* Dutch *Fortifications.*

Although the *Dutch* have had much Experience, and by their Ingineers have filled the World full of their Books and ways of fortifying, yet I find not that they have added any one Conſiderable Rule or way for advancement of this Art; their Books are pompous, and full of laborious pains in Triangles, and other Mathematical learning, but all that is more for Curioſity than Uſe. They fix the Curtain and Face upon an immutable Number, and let their Interior Polygon vary, which as it is moſt improper,

per, inartificial, and not so useful, either in Regular or Irregular Fortifications, as those that deal with the Interior Polygon; so it more involves the Work into intricate Rules and other disadvantages, as will appear by the following Discourse: I shall not trouble you with *Marolois*, and those more ancient, because *Dogen* has summed all up that either they or *Fritach* has writ.

1. Fritach *Printed at* Leyden, 1635. *in his Mechanical Ways.*

For all Forts above the Pentagon.

Divide the Interior Polygon into 5 parts, take $\frac{1}{5}$ thereof for the Gorge and Flank, and $\frac{2}{5}$ for the Capital. In a Square leave no second Flank, but take the Gorge and Capital as before, and raising a perpendicular for the Flank from *a* draw *a c*, which shall determine the Flank and Face: and for the Pentagon divide the Curtain into 5 parts, and take four of those parts for the Faces, the Gorges and Flanks remaining the same as before, viz. $\frac{1}{5}$ of the Interior Polygon, which Faces *f a* set off from *f* will cut the Capital at *a*.

And supposing the Interior Polygon to be 1000, then for all Forts above the Pentagon, the Gorges and Flanks to be each 200, and the Capital 400. For the Pentagon, the Gorges, and Flanks, each 200 as before, but the Face to be 240.

For

For the Square the Gorge to be 200, and Capital 400, the Face to be drawn to the point of the Curtain and Flank *c*.

And note, that the Flanks ſtand at right Angles with the Curtain in all the *Dutch* Fortifications.

2. Dogen, *printed at* Amſterdam, 1647.

Maralois, *Fritach*, *Goldman*, and *Dogen*, all agree to make the Curtain and the Face as *Dogen* has appointed by his 4th manner, and *Tacquet* by his Sixth, viz. the Curtain 446 *Engliſh* feet, the Face $\frac{2}{3}$ thereof viz. 297 Feet, the Angle of the Bulwork to be half of the Angle of the Polygon, more by 15 or 20 degrees, the Angle forming the Flank always 40 degrees. To work this upon Paper by Scale and Compaſſes without any Calculation, I have thought of this way following in an Hexagon, the ſame work fitting all the reſt.

Draw a line *a M*, which ſhall repreſent part of the outward Polygon, the half of the Angle at the Polygon for the Hexagon you have Chap. 1. § 9. to be 60 degrees, which added to 20 makes 80 degrees for the Angle of the Bulwork *f a f*, and 40 for half *f a p*; therefore firſt upon *M a* at the point *a* ſet off an Angle of 60 degrees, draw the Diameter or part of it *a p o*, which gives the poſition of the Capital Line. Likewiſe at *a* upon *a p* ſet off an angle of 40 for the half Angle of the Polygon, and draw *a f*, taking then from your Scale 297 the length of the

the Face, ſet it from *a* to *f*, at *f* let a perpendicular be drawn to *a M*, and lengthen it to *c*, and further to *f c*; at *f* make an Angle of 50 degrees, which is the Complement of the Angle forming the Flank, draw the line *f p*, and mark where it cutteth the Capital line *a p* as it doth at *p*, that is the middle of the Gorge and point of the interior Polygon; having *p* take the nearest diſtance to the line of the outward Polygon *a M*, and by that means draw *p p* parallel to *a M* to a length ſufficient, *p c* is the half Gorge, and take from your Scale 446, and ſet it from *c* to *c* which is the Curtain, and ſet further *c* equal to the other *c p*, that gives you the length of the Interior Polygon, and by drawing as before the reſt of the Baſtions, you may finiſh your whole Fort of 6 Baſtions; and laying all down in an handſom large Scale, you will find, by meaſuring the length of each line upon it, the proportions of the parts of the Fort, viz. the Gorge *p c* 148½ feet, the Flank *c f* 124½ feet, the Capital *p a* 261. The Interior Polygon 2 *p c* + *c c* is 743 feet. The Exterior Polygon *a a* 1004 feet, the leſſer Diameter *p o* 743. The line of Defence *a c* 750 Feet.

And the Angles of the Baſtion 80 degrees as before, the Angle of the Shoulder *a f c* 110 degrees, the Angle of the Tenail *a t a* 140°.

This way, though it has good proportions, is troubleſome, and not ſo good as to work by the inward Polygon, as by the next Rules will appear.

3. *Rules*

3. *Rules found out and ſet down by the Emperour* Ferdinand 3d, *Anno* 1650, *well approved, by turning the Fortifications of* Fritach, Dogen, Goldman, *and* Faulhaberus, *out of the way of working by Angles, into Lines.*

This work of the Emperours, called *Amuſſis Ferdinandea*, was firſt publiſhed 1654, at which time *Gaſper Schottus* that Learned Jeſuite, had thoughts to have printed it at *Rome*, but durſt not; take his own words, (*ni & Cæſaris Ferdinandi tertii tunc viventis, Auctoris libri, offenſionem timuiſſem:*) afterwards 1662 he printed it with ſome Annotations. The Emperour ſets down an Univerſal way to lay down the Sides or Lines of any Fort, by the 60 Prop. thus. The Interior Polygon to be 66, the Gorge 15, the Flank 12, and the Capital 24. Or in leſs Numbers, Interior Polygon 22, Capital 8, Gorge 5, and Flank 4. Or yet, making the Interior Polygon 1000, the Capital 363, the Gorge 227, and Flank 181. And to lay down the work, divide *p p* into 22, of theſe take 5 for *p c* the Gorge, 8 for *p a* the Capital, and 4 for *c f* the Flank, which muſt be ſet at right Angles to the Curtain *c c*.

This is an Epitome of all the *Dutch* Fortifications, and is general excepting for the Square, which muſt have no ſecond Flank, and may very well be preferr'd: for take the Emperour's

rours words in English. *The delineating of Fortifications by Angles is much harder and more uncertain than by the Sides, for the knowledge of the Angles doth not so much concern the delineating Forts as calculating the Triangles* &c. which, people that have any Imployment else, may easily neglect.

IV. *Of some Fortifications, wherein the* Flank *stands at right Angles with the* Line of Defence, *approved and made more plain by his Majesty of* Great BRITAIN, C. II.

Count Pagan, a person of good Account, an Expert Souldier, having been present and concern'd in 20 several Campaignes, and in many considerable Sieges, at the last whereof, viz. the first Siege of *Arras*, he was unfortunately shot with a Musquet Bullet in one Eye, but lived a long time after in Retirement, a very good Scholar and Mathematician; there are many persons yet living are witnesses of his worth. He I say in his Retirement and peaceable life was the Author of many good Pieces, amongst which was his *Fortifications*, printed at *Paris* 1645, the Product of his serious Considerations upon the whole matter of Fortifications, having found that all the *Dutch* Fortifications could not hold out an Enemy any considerable time, by reason they had no strength of great Guns, and those they had coop'd up in the Flanks, he therefore ordered the Flanks another way; and after his manner

manner one may eaſily trace out the work of all ſort of places, with great readineſs and juſtneſs, and ſo that the Pentagon in his way will incloſe as much Ground as the Hexagon another way; he oppoſes Artillery againſt Artillery, and Mine againſt Mine, and by theſe means gets time, which is all can be expected from a Fort.

He works by the outward Polygon, but I have added two other Numbers to work by the Interior. Firſt I ſhall ſet down this little Table, fitted for all outward Polygons, betwixt 1200 Feet and 600 Feet.

The length of the Ex. Pol. in E. feet.	1200.	1080	960	820	720	600	*a a*
The half of it. ——	600	540	480	410	360	300	*M a*
The length of the Curtain. ——	425	364	304	305	234	164	*c c*
The half of it. ——	212.5	182	152	152½	117	82	*M c*
Length of the Perpendicular. ——	180	180	180	150	144	138	*M t*
Complement of the Perpendicular. ——	63¼	60½	57	55	46½	38	*t m*
Compl. of the line of Defence. ——	222	192	162	162	126	90	*t c*

For to delineate this work draw a line, about the middle whereof, as at M, ſet off *M a*, the half of the Exterior Polygon, taken from a Scale of equal parts; 600 Feet for the Fort Royal, 540 for the Mean, 480 for the Small Fig. 20. B. 6.

Royal, or for a ſmaller Fort ſome of thoſe three that follow. This Example ſhall be for a grand Royal Fort, therefore is 600, which makes the Exterior polygon 1200 Feet. Having found *M a*, let fall a Perpendicular *M m*, upon which from M out of the Table of Perpendiculars take 180 from your Scale, and ſet it from *M* to *t*, and draw *a t e*, take at length 222 Feet from your Scale, *viz.* the Complement of the line of Defence, and ſet it from *t* to *c*; draw *c c* for the Curtain, erect *c f* a perpendicular to the line of Defence *a c*, ſo is *a f* the Face, and *c f* the Flank; upon the point *a* ſet off the half Angle of the Figure *o a a*, and that will determin the Center of the Figure *o*, (as if it had been a Pentagon, the Angle would have been 54, if an Hexagon 60) and the Gorge *p c*, and the Capital *p a*, which you may meaſure by your Scale, and ſet each meaſure upon the reſpective Line, as in the Example.

Fig. 20. B. 6.

To work by the Interior Polygon, lay down a Line long enough about the middeſt, as at *m* for the great Royal, and ſet off 212½ taken upon your Scale from *m* to *c* both ways, and raiſe the Perpendicular *m M*, take 63¼ from the Scale, being the Complement of the Perpendicular *M t*, and ſet it from *m* to *t*; ſet the Perpendicular *M t* 180 from *t* to *M*, and from *M* draw a Parallel to *c c*, draw the Lines *c t a*, and at *c* raiſe Perpendiculars *c f*, which ſhall determin the ſame work as before.

Fig. 20. B. 6.

But if the outward Polygon be to be leſs than 1200,

1200, you must choose in the upper line of the Table one that is next to it, (for those are the outward polygons from 1200 feet to 600) and under that Number so chosen you have the correspondent Perpendiculars and Complements to work as before.

Lastly, the proportion of the great Fort Royal, supposing the Exterior polygon be 1000, will make the perpendicular *Mt* to be 150, and the Complement of the Line of Defence *tc* to be 185, which may serve for a general Proportion, be the length what it will.

His *Majesty* has much facilitated this work, as will appear hereafter. But to fortifie a Square, the Proportions are to be alter'd thus.

	Great Royal.	*Mean.*	*Petit R.*
Perpendicular ———	162.	144.	126.
Complement of the line of Defence to be delineated as before.	228.	198.	198.

There is yet another way. The Line of Defence standing at right Angles to the Flanks of the Interior Polygon, that will give a very good proportion without second Flanks, by this Table, which supposes the Interior Polygon to be 1000. Then

	4	5	6	7	8	9	10	Strait line.
Capital.	398	437	367	333	312	300	291	233
Gorg line	155	196	203	242	252	260	263	300

Fig. 20. *Ex.* For an Hexagon. Divide the Interior Polygon into 1000, or take the Interior Polygon and set it upon a Sector in 10 and 10. Then drawing out your Polygon, take out of that Scale or Sector .367, and set it from *p* to *a* round for the Capital, and take out 203 for the Gorges, draw the Line of Defences *a c*, and set the Flanks at right Angles upon the Lines of Defence, which in all the Polygons will be equal.

Thus have I set down the several ways and rules for laying this fundamental Ground-line from the most considerable Engineers of this last Age, and shall in this Table following give you their proportions for the Capital, Gorge, Flank, and Curtain, which constitute the Bastion, and for the length of the Curtain, supposing the length of the Interior polygon to be 1000, that thereby a better judgment may be made, which to choose for the best Proportion.

Capital

	Capital.	Gorge.	Flank.	Curtain.
Tenſini.		143	143	714
Ped. Sardi.		187	187	626
Fennaro.		125	138	750
Furnier, &c.	288	166	166	666
De la Mont.	333	200	150	600
Maneſſon.	333	200		600
French Conqueſts.		200	240	600
Dogen.	351	167	200	600
Fritach.	400	220	200	600
Emperour.	363	227	181	546

Out of all which, it will be moſt agreeable to theſe Authors, and to practice, to take 333 for the Capital, 200 for the Gorge and Flank, which will leave 600 for the Curtain, according to moſt; ſo that this will lengthen *De la Monts* Flank, and will agree with *Maneſſon*, who makes the Angle of the Flank and Curtain 98°, and ſo lays it more open for uſe, and yet not ſo much as to ſubject it to the ruin of the Beſiegers.

Therefore for a General Rule, where the Flank and Curtain ſtand at right Angles, take $\frac{1}{3}$ of the Interior polygon for the Capital, and $\frac{1}{5}$ for the Gorge and Flank, and where there is no ſecond Flanck as with *Maneſſon*, then make the Capital and Gorge as before; and draw the Faces to the point of the Flank and Curtain, all which agrees neareſt to *Sardi*, and the

Emperours proportion, though for Irregular Fortifications all may receive Alteration as neceſſity requires. The Proportions expreſſed in the former Table will be reduced to any convenient length of an Interior Polygon, by multiplying the Length given by any of thoſe Numbers, and cutting off three places. As for Example: ſuppoſe in the *Emperour*'s way, the length of an Interior Polygon was given 550 Feet, what ſhall be the length of the Capital, Gorge, and Flank? Multiply 550 by 363, and cutting off three of the laſt places, the Capital will be 178 Feet; 550 by 227, the Gorge will be 125 Feet, and the Flank 99 Feet.

Thus to any reaſonable proportion of the Interior Polygon (which muſt not much exceed 800, nor be leſs than 500) any of the former Rules may be proportioned.

§ 4. *Of laying down upon the Ground any of the former Fortifications, either with Inſtruments or without.*

When you intend to do this, you muſt make a Plat of your Fort upon large Royal Paper, or elſe upon Papers paſted together, or Velom, by a Scale whereby Feet may be diſtinguiſhed, that is ſuch a Scale as may have forty or fifty Feet in an Inch at moſt; and if it be a Regular Fort as before, you ſhall not need deſcribe above two half Baſtions from the Center, for that will be ſufficient.

This

This Plat thus drawn, and upon every Line the length ſet down, and all Angles proper expreſſed, will not onely be uſeful for laying down the work, but for meaſuring the Solidity of the Ramperts, and Parapets: ſee the 20th Figure.

If it be ſuch a place, that from the Center of the Fort all the Angles may be ſeen, then by *Chap.* 1. §. 5. either with an Inſtrument or Chain of 30 Feet, ſet out the Angles at the Center of that Polygon that your Figure is for. Mark out by *Ch.* 1. §. 1. theſe Diametral lines, & meaſure out their lengths, as you find them by your Plat. From *O* to *p* ſet Pickets or Stakes upright at all the *p p*s &c. leaving one in the Center, Trench or Lock-ſpit out all the Polygons round about, after which mark out the Gorges *p c*, and at *c* either ſet out a right Angle by §. 2. *Chap.* 1. or an Angle greater than a right Angle if required, and mark out the Flank *c f*, ſo have you the Gorges, Flanks, and Curtains. Upon the Diametral line extended beyond *p*, meaſure out the Capital *p a*, Lock-ſpit the Faces and Flanks, ſo is your Fort lined out for the Ground Line. Fig. 22.

But if there be Houſes and Obſtacles in the way, that from the Center all may not be ſeen, then muſt you mark any one ſide out and meaſure it, at each end ſet off the Angles of the Figure or Polygon, (which is always the Complement of the Angle of the Center to 180°) and draw ſide after ſide till all be finiſhed, and then finiſh the Baſtions as before. Several Tryals

may be made 'till you are ſatisfied in each particular by a little pains taking, the practice of a few hours upon the Ground, will inable one to underſtand more than many Sheets in writing can do without it. And it being required from an Ingineer to give in the quantities in Acres that he ſhall take away from the Subject, in order to ſatisfaction, it will be expected that he can draw a Plat of the Grounds at hand, and will practice himſelf fully, that he may be able to anſwer Expectations, and the Difficulties that ſhall fall out.

Laſtly, though I pitch upon $\frac{1}{3}$ part of the Polygon for the Capital, and $\frac{1}{5}$ for the Gorge and Flank, and commend *Travaux de Mars* his way of opening the Flanks, and likewiſe Count *Pagan*'s way; yet, as you may ſee by fortifying a ſtreight line Figure, you have liberty experimentally to alter any of the Proportions, as may beſt ſerve the occaſion and place; as you may ſee in the *Fig.* 23. where it may not be allowed in Count *Pagan*'s way, or *Maneſſons* either, without ſome alteration.

Fig. 23.

CHAP.

CHAP. III.

The Use of a Joynt-Rule or Sector, made upon the former Proportions, for Fortifications and Gunnery.

§ 1. *The Description of the Lines.*

THere are two *Edges* (when the Ruler is opened ſtraight, and made in form of a plain Ruler) the outward Edge being the juſt length of an *Engliſh* Foot divided into 12 Inches, and every Inch into Ten parts. Upon the inner Edge is wrought a Table, what weight of Powder is allowed for proof of all Guns caſt in *England*, viz. for whole Cannon 30l, Baſtard Cannon or Cannon of Seven 24l, for Demi-Cannon 20l, for 24 Pounders 17l, Whole Culvering 14l, for 12 Pounders 10l $\frac{1}{4}$, for Demi-Culvering 9l, for 6 Pounders 6$\frac{1}{2}$, Saker 5l $\frac{1}{4}$, and Mynion 4l.

Keeping the Joynt-Ruler ſtill open and ſtraight, and begininng at the firſt numbering of Inches, upon both Sides, there is marked the Heights or wideneſs of the Bore of each Piece at the Mouth or Muzzle of the Piece, *viz.* at two Inches,

Inches and almoſt $\frac{1}{10}$ is the Falconet marked F N, at two Inches $\frac{1}{10}$ and almoſt a half is Falcon marked F, almoſt at 3 Inches is 3 Pounders, at 3 Inches $\frac{1}{10}$ and a little more is ſet Mynion marked M; and ſo, as you will find, Saker marked S, Six Pounders marked 6. Demi-Culvering marked D C, 12 Pounders marked 12. Whole Culvering W C. 24 Pounders 24. Demi-Canon D C. Cannon of 7 Inches bore marked B C. Whole Cannon, or Cannon of 8 Inch Bore, marked W C. This is done on both ſides, and by every nature is ſet on one ſide the weight of the Shot in Iron, *viz.* for W. Cannon 63 l weight, for BC, 42 l; for DC 32 l, and ſo of all the reſt: and on the other ſide is ſet the weight of the Powder, allowed to each Sea-Gunner for Service, *viz.* for Cannon of 7 or Baſtard Cannon 18 l of Powder, (whole Cannon is not uſed at Sea,) for Demi-Cannon 15 l, for 24 Pounders 11 l, for whole Culvering 10 l, for 12 Pounders 8 l, for Demi-Culvering 7 l, and ſo of the reſt. If the worthy Sea-Captains would intereſt themſelves ſeriouſly to ſet truſty perſons to ſee the Cartridges juſtly filled with this Allowance, and at their leiſure to turn out the Powder out of ſome Cartridges already fitted, and weigh it, (for there are Scales in each Ship which they may command) to ſee that the Gunners wrong not their Guns, they will find their Bullets fly further, and do more Execution; for the Officers of the Ordnance know, that Powder proved Tower-proof, is a fifth part ſtronger

ger than any *Dutch* Powder that has been brought thither, though that has been ſome thouſand of Barrels in theſe two laſt Engagements. All the reſt of the lines iſſuing from the Center, or middeſt of the Joynt whereof, if the Ruler be opened a little: there are four parts, two of one ſide, and two of another, turning that ſide upwards that hath *Italian* and *French* upon it. Firſt, beginning with *Italian*, the firſt line hath *Tenſini* 1630, the Authors Name and Year when writ: it hath eight Diviſions, marked with eight Braſs Centers. The firſt is the Flank of the Square (*f* 4), the ſecond the Flank of the Pentagon (*f* 5), the third is the Gorge and Flank of all Figures above the Pentagon marked (*g f*), the fourth is the Gorge of the Pentagon (*g* 4), the next is the Gorge of the Square (*g* 4), the ſixth is the point of the 2d Flank of the Pentagon (2 *f* 5), the ſeventh is the 2d Flank of the Hexagon, and all above, mark'd (2 *f* 6); the eighth and laſt point repreſents the middle of the Exterior Polygon, there is ſtampt on beſides 1200 *Engliſh* Feet for the Interior Polygon.

The ſecond line on the *Italian* part hath *Pedro Sardi* 1638 on it, and 5 points; the firſt (*g f*) is the Gorge and Flank for all Figures; the 2d is the ſecond Flank for the Square and Pentagon, the third is the 2d Flank for the Hexagon, the 4th the 2d Flank 7, 8, 9 *&c* figures; and the fifth for the middle or half of the Interior Polygon. The third line is a line of Chords for dividing Circles,

cles, and will ſerve to any Radius that it may open to, to that end at 60 degrees has a Braſs Center to open it by, it is divided into 72 degrees, it is marked with the word *Chords*.

The Fourth, is a line of Regular Polygons for the deſcribing Regular Figures, which it doth with great eaſe, and are the Chords of the Angles of each Figure, and might have been taken out of the Chords but for Confuſion. The Point for a Pentagon marked (5) is ſet at 72 degrees its Angle, for the Hexagon at 60 marked (6), for a Heptagon at 51° 43′, for an Octagon at 45°, and ſo of the reſt.

The Second part of the Ruler hath *French* ſcales upon it, ſignifying the Fortifications uſed by the *French*; the firſt two lines iſſuing from the Center are thoſe mentioned before, *viz.* line of Regular Polygons, and line of Chords, and need no farther Explication.

The third hath *De la Mont & Maneſſon* 1671. upon it, being two Ingineers modern amongſt the *French*, both theſe make the Interior Polygon to be 768 *Engliſh* Feet, and both of them make the Gorge marked (*g*), and Capital marked (*Cap.*) to be equal and the ſame; they differ only in the Flanks, *De la Mont* making it fixed, marked (*f*), the other makes the Angle of the Curtain and Flank 98 degrees, marked (*f c* 98°) and has no ſecond Flanks.

The Fourth Braſs Center of this Line, and ſo of all the reſt of theſe, both before-going, and what ſhall follow, are for half the Interior Polygon.

The

The Fourth hath only the Gorge and Flank marked upon it, of the Fortifications of the *French* at *Aeth* and *Liſle* 1670, and has no ſecond Flank, but the Faces drawn to the Point of the Flank and Curtain, and the Flank at 100 degrees with the Curtain, and ſo we have done with one ſide of the Ruler.

The next ſide hath two parts, *Dutch* and Count *Pagans* altered by His Majeſty. On the *Dutch* quarter are 4 Lines.

The firſt is to be read thus. The Angle of the Baſtion is equal to the Angle of half the Polygon more by 15 or 20 degrees. The Angle forming the Flank is 40 degrees. Curtain to be 446 *Engliſh* Feet, the Flank 296, *Dogen* 1647, and is the Rule for *Fritach*, *Tacquet*, *Maralois*, &c.

The ſecond Line has *Fritach* 1635 upon it, it hath 5 Braſs Centers; firſt is the Flank for the Square, ſecond is the Gorge and Flank for all Figures above. The third is for the Capital of all, the 4th the Face of the Pentagon, and the laſt for half the Interior Polygon.

The third Line is the Emperour *Ferdinand* 3d, of very happy memory, 1650, has on it 4 Braſs Centers, firſt for the Flank, ſecond for the Gorge, the third for the Capital, and the fourth for half the Interior Polygon, which he makes 800 *Engliſh* Feet.

The fourth Line is a Line of equal Diviſions, (marked, *Equal parts*), it is divided into 12 or 120, and ſerves for quickly dividing any Line given

given into any even or uneven parts, and I take 12 to be better than 10, because of its Aliquot parts) to be put on any Scale.

The last quarter hath 3 Lines upon it, one of equal parts explained before; the second Count *Pagans* 1650, where he makes the Exterior Polygon 1250 English Feet, and hath no second Flanks in his Forts; it hath 5 Brass Centers, the first marked (*p* 4) is for the Perpendicular of the Square, the second (*p* 5) is for the Perpendicular of the Pentagon, and all Figures above; the third is for the Complement of the Line of Defence of the fourth, and the fourth the Complement of the Pentagon and above, marked *cc* 4, and *cc* 5. The fifth for half the outward Polygon.

The third and last is His *Majesties* that now is, (whom God preserve) *C. II.* which is an alteration of the last, and hath two parts for its work, as will appear in the Uses: it hath 7 Brass Centers. The first marked (*6 part*) is the 6 part of half the outward Polygon, or $\frac{1}{12}$ part of the whole outward Polygon; that is, for one work.

The second is the perpendicular of the Square, the third of the pentagon, the 4th the perpendicular of the Hexagon and all above, the 5th the Complement of the Line of Defence for the Square, the sixth for the pentagon and all above, marked both (4. 5. *cc*), the last for half the Exterior polygon.

And all these Points for the Fortifications are

are found by the Proportions in the ſecond Chapter: For if the Interior Polygon be divided into 1000, then of the Line from the Center of the Joynt to the outermoſt Point, which (as was ſaid before) repreſents half the Interior Polygon, be divided into 500 equal parts, the Numbers expreſſed in thoſe ſeveral ways, and taken from a Scale ſo divided, will find thoſe Points (for Example) in the *Emperours* way, from a Scale of the ſame length of the lines of the Inſtrument divided into 500 equal parts, the Flank will be found at 181, the Gorge 227, and the Capital 363, and ſo of the reſt. The other Lines are known to moſt.

§ 2. *Of the Uſes of the Joynt-Rule.*

1. *Of the Line of equal parts.*

To divide any Line given into any number of equal parts, or to give the third, the fifth, the ſeventh, or any other part of a Line given, ſuppoſing the Sector will open to it.

Suppoſe a Line were required to be divided into Eleven parts, take the length of the Line in your Compaſſes, and opening the Ruler, ſetting one Foot in the diviſion of 110, which is the 11 large diviſion on that Line; open it ſo, that the other point may reſt in 110 on the other ſide, ſo have you that Line divided into 11 parts. For opening and ſetting the Compaſſes at 10 and 10 that $\frac{1}{11}$ part, at 20 and 20, that is $\frac{2}{11}$, at

30 and 30 is the 3^d part or $\frac{2}{11}$, and ſo for the reſt. After the ſame manner you may have the third part of a Line, opening the Compaſſes in 30 and 30, and taking diſtance betwixt 10 and 10 for $\frac{1}{3}$; or if you had opened it in 120 and 120, and took it over in 40 and 40, it had been the ſame; for 40 is the $\frac{1}{3}$ part of 120 as 4 is of 12. One of the Lines from the Center to 120 will ſerve for a Scale of equal parts, divided into 120 or 1200, then every 10 muſt be imagin'd 100; or you may uſe it by opening to any length for Scales as you need. For ſuppoſe a Line of 4 Inches long is to be divided firſt into ten parts, ſetting it upon 10 and 10, you have all the Tens, and taking a Tenth and ſetting it again in 10 and 10, you may divide one of the Tenths into ten parts again &c.

2. *Of the Line of Chords.*

The uſe of this is to meaſure or lay down any Angle upon Paper.

The Radius or Semidiameter of that Circle, for which the Inſtrument will ſhew the degrees or Arches, is repreſented always by the diſtance of the two braſs Centers at 60 and 60 when the Ruler is opened; therefore when any Angle is to be meaſured, ſet one point of your Compaſſes upon the Angular point (*a*), and extend the other as far as is reaſonable, and make the Fig. 7. Arch (*b c*), and with your Compaſſes unremoved open your Rule to that diſtance betwixt 60 and

and 60, and ſo let the Rule lye; then with your Compaſſes take the diſtance betwixt *b* and *c*, and carry that along the two Lines of Chords on your Ruler, 'till it reſt on like Diviſions on both Lines, as here it will on 42 degrees, that is the Angle required.

And to lay down an Angle propoſed is the Converſe. Suppoſe the Line be *a b*, open the Joynt-Rule in 60 and 60 to a convenient length, and ſetting your Compaſſes in the Braſs Centers take out the diſtance, with which ſetting one Point upon *a*, deſcribe an Arch large enough *c b*; then with your Compaſſes take the diſtance of the degrees that your Angle is to be, as here (42) from between 42 and 42 on your Line of Chords, and ſet it from *b* to *c*, draw *a c* and that is the Angle required. Fig. 7.

But you muſt note, that your Line goes but to 72 degrees, therefore if you deal with a greater Angle, it muſt be done at twice, or more if need require.

3. *Of the Line of Polygons:*

This has on it eight ſeveral Points repreſenting the Sides of Polygons, from a Pentagon to twelve Sides, beginning at 5 for a Pentagon. It is requiſite in all Regular Fortifications to deſcribe the Polygon on which the Fort is to be raiſed; and that is by giving the length of one of the Sides, and how many Sides the Fort is to be of; then by this Line you may eaſily find

the Center and Radius of the Circle, that will contain those Sides, thus.

Fig. 21. Take the length of the Line (*a a* or *p p*) in your Compasses, which you propose to be the side of a Pentagon, and open the Sector to receive the Compasses in (5 and 5) and hold it there, 'till you place your Compasses in (6 and 6), with that opening, setting one end on (*a*), make an Arch about (*o*), then removing it to the other (*a*) cross the Arch at (*o*), which is the Center of a Circle that the Pentagon may be inscribed in, and (*a o*) the Radius. But if a Circle and the Semidiameter be given (*o a*), then opening the Joynt thereto in 6 and 6, the distance betwixt 5 and 5 will give the side (*a a*) of a Pentagon, (6 and 6) of an Hexagon, (7 and 7) of an Heptagon, to be inscribed in that Circle, the side of an Hexagon being the Radius it self.

4. *Of the Lines for Fortifications.*

1. By the last *Sect.* fit the side of your Interior Polygon to a Circle, and draw out the Po-
Fig. 20. lygon. Whereof (*o*) to be the Center, and *p p* the Side. In all the Lines which are made for the Interior Polygon, divide the Side *p p* in halves at (*m*); then in them all, the *Italian*, *Dutch*, and *French*, take the half Polygon (*p m*) in your Compasses, and fitting one end in the fartheſt Brass-Point from the Center, that has neither Figure or Letter by it of any of those six Lines, and keeping your Compasses fix'd, open

open the Joynt-Rule, that the other Point turned about may touch the inner Edge of the other ſide of the Joynt-Rules: then is the Inſtrument fitted to find the Lines requiſite for to draw the Fort, after the Rules that the Lines directs which you have choſen. Thus beginning with—

Seignior Tenſini. Having fitted the $\frac{1}{2}$ Interior Polygon (*p m*) to that Line by the laſt Rule, for all Forts above the Pentagon, ſet one Foot of your Compaſſes in the third Point, marked (*g f*), and taking the neareſt diſtance to the other ſide of the Ruler, ſet it from *p* to *c* for the Gorge, and raiſing a Perpendicular *c f*, ſet it again from *c* to *f* for the Flank, ſo have you the Gorges and Flanks round about the Fort. Now for drawing the Faces, ſet the Compaſſes (2 *f* 6) of that Line, and take the neareſt diſtance to the other ſide as before; ſet it from *p* to *d* the Point of the ſecond Flank, and laying a Ruler upon the Points *f* and *d*, draw *f a* for the Face, which round about will complete the Ground-line. Fig. 20.

But if you had been to have deſcribed the Lines upon the Square or Pentagon, you muſt have taken (*g* 4) for the Gorge of the Square, and (*f* 4) for the Flank of it, and it is to have no ſecond Flank, but the Face to be drawn from the Point *c* by *f* to *a*, and for the Pentagon it has its own Gorge and Flank, and for the Face take the neareſt diſtance from (2 *f* 5) to the other ſide, and ſet from *p* to *d* to draw the Face *f a* as Fig. 20.

before; this being well observed, the rest being wrought much alike, will not need so much Explanation.

Pedro Sardi is the next. Fit the half Polygon (*p m*) to this Line, as was taught generally for all; take out the neareſt diſtance from the Point (*g f*) for (*p c*) the Gorge, and for (*f c*) the Flanks, and mark them all about the work whatever the Polygon be; but to find the points (*d*) of the ſecond Flanks, or the points where the Face will come to, you have one for the ſecond Flank of the Square and Pentagon, another for the Hexagon, and another for the 7 8 9, and above, which you muſt uſe as your Polygon given ſhall be.

The next is *De la Monts*, which after you have fitted to the $\frac{1}{2}$ Polygon as before, take the diſtance from (*g*) to the other Edge, and ſet that about from (*p* to *c*) for the Gorge, and the diſtance from (*f*) for the Flank (*c f*), being at right Angles, and the diſtance (*Cap.*) being the third Braſs Center for the Capital Line (*p a*), draw lines from *a* to *f* for the Face: this is general for all Polygons.

Monſieur Maneſſon, whoſe Name is upon the ſame Line, has the ſame Gorges and Capitals as the laſt hath; but for his Faces and Flanks he determines them thus: Make the Angle of the Flank and Curtain (*f c c*) to be 98 degrees, and drawing a line from *a* the Point of the Baſtion to *c* the Point of the Flank, it will find out *f a* the Face, and *f c* the Flank. This

Work

Work has no ſecond Flanks at all, but the Flanks are the larger.

For the Fortifications of *Aeth* and *Lyſle* ſet off the Gorges and Flanks as before, and draw the Faces to the Point of the Flank (*c*), for they have no ſecond Flanks at all.

On the other ſide ſtands the *Dutch* Lines, that of *Dogens*, *Tacquets*, *&c.* is explaned in the ſecond *Chapter* §. 4. and that of *Fritach* 1635, has the Flank, Gorge, and Capital general for all Polygons, only the Face of the Pentagon has his ſeveral Points to be noted.

Next follows the *Emperour's* way, which, as it is one of the beſt, take more fully.

Take half the Polygon in your Compaſſes, and placing one foot in the Point fartheſt from the Center, open the Sector 'till the other turned about be a Tangent to the other ſide of the Ruler on the inner Edge; this done, the Sector fixed, ſetting one foot in (*g*), and taking the neareſt diſtance to the other Edge, ſet that from *p* to *c* for the Gorge, work the ſame for (*f*) the Flank, and for *Cap.* the Capital, and draw the lines *c f* and *a f*, and complete the Fort.

Now we are come to His *Majeſties* way, which he has cauſed to be obſerved at *Sheerneſs* and *Tilbury*, being ſomething altered from Count *Pagans*, and one Rule may ſerve them both. Firſt take half of the Outward Polygon *a M* (for here the work goes upon that) and fit it to be a Tangent to the other Edge of the Sector, from the extreme Point of either the Fig. 20.

two Lines of His *Majeſties* (2) or Count *Pagans*, and fixing the Sector there. Then if the Polygon be a Square, ſet one point of the Compaſſes in (*p* 4), and take the neareſt diſtance to the other Edge, which ſet off in a Perpendicular from (*M*) to (*t*). Draw the Lines *a t ç* both ways from *a* of a ſufficient length, then ſetting your Compaſſes in the Point (4 *c c*), take the neareſt diſtance, and ſet that from (*t*) both ways to *ç* for the Complement of the Line of Defence; then from *c* to *c a* raiſe the Perpendicular *c f*, which makes the Flank *c f*, and Face *a f*, draw *c c* for the Curtain, and ſo for the reſt of the Baſtions.

If the Polygon be a Pentagon, then work by (*p* 5) for the Perpendicular, and (5 *c c*) for the Complement, which in Count *Pagans* Line will ſerve for all higher Polygons. But the other of His *Majeſties* has (*p* 6) for the Perpendicular of the Hexagon, though (5 *c c*) will ſerve for the Complement of the Pentagon and all higher Polygons.

There is yet another way by His *Majeſties* Line, by the firſt Braſs-Point marked (*6 part*), for having ſet the Sector to the half Exterior Polygon *a M*, then ſetting one foot of the Compaſſes in (*6 part*) take the neareſt diſtance to the other ſide, and ſet it three times from *a* to *q*, and ſet it once from *q* perpendicularly to *f*, continue *a f* the Face to *c* and farther, let fall a Perpendicular from *f* upon *a c* the Line of Defence to *ç*, then ſhall *f c* be the Flank, and *c c* the Curtain.

After

After any of these Draughts, made by any of the Rules aforesaid, by this Instrument, if it be required to set upon each Line his Measure, and each Angle the Quantity in degrees, take the Length of the outward Polygon, which in the biggest Figure ought to be 1200, and setting that Opening in the Line of equal parts, upon 120 and 120 you will find in the Example of the Hexagon the Face to be 317, the Flank to be 189, the Capital to be 322, the Curtain to be 480, and the Gorge to be 199, the Angle of the Bastion to be 83 degrees 8′, the Angle of the Flank and Curtain to be 108 degrees, 26′, and the Angle of the Tenail to be 143 degrees, 8′, which may be set to their places severally, as in *Fig.* 20. Fig. 20.

5. *Of the Use of the Line of Inches.*

This will serve to measure the Length of Guns and other Lengths, it will set out a Rod or Gad of ten Feet or 9 Feet fit for use, and it will try the measure that Workmen bring, whether they be true or no, and is of general use for many things.

6. *Of the use of the Line of Height of Guns, with the Weights of Shot and Powder for Service.*

If you put the beginning of Inches at the end of the Ruler into the Muzzle of a Gun, and

hold the Ruler in the middeſt of the Bore, by ſtopping your finger on the other ſide of the Bore, or looking at what point of your Ruler it falls, it ſhews you the Name of that Gun you took the meaſure of, and on the one ſide you have the Weight of the Shot that Gun carries, and on the other the Weight of the Powder allowed for Service. Suppoſe ſuch a Guns Bore reached to four Inches and a quarter, then you will find it was a Demi-Culvering, and carried a Nine-Pound Bullet, and the allowance for Service ſeven Pounds of Powder; which Rule ſerves for all Guns.

On the Inſide of the Ruler there is ſet down what Powder being new and good, is allowed for Proof.

But notice is to be taken, that for Guns for Land-Service for Battery, that are double fortified, there is a greater Allowance made both for Proof and Service.

CHAP.

CHAP. IV.

Of the Rampire, Parapets, Tenails, Mote or Ditch, and Covert-way.

§. 1. *Of the Rampire. It is a great maſſy Bank of Earth, made round about the Fort, incloſing it to reſiſt the Enemies great Shot, to ſave the Buildings of the place from ruine, and hinder their Deſcent into the place.*

FOR the better underſtanding of the Terms belonging to this part, this Rampire with the Breſt-work upon it is imagined to be cut perpendicularly to the Horizon, which ſome call the *Profile* or *Orthographical Section.*

Thus in the Figure 25, the Superficies R A Q T is a Section, and repreſents the Length, Bredth, and Heigth of the ſaid Rampire or great Bank: R A being the Horizontal or Level Ground-line drawn at the foot, R being the end within the Fort, and A next the Mote or the Point on the Outſide.

The thickneſs at the top of the Rampire is T Q, and the heigth of it from the Level-line R A, is S T or O Q Perpendiculars to it.

And

And becauſe common Earth, let it be of what ſort ſoever (whereof theſe Rampires are made) will not by reaſon of its brittleneſs be built upright, but muſt be ſloped to bear up the top; therefore the two lines R T and Q A repreſent the Slopes, R T is the inward Slope, and Q A the outward Slope, and S T being a perpendicular and drawn from the upper point of the Slope-line, R T terminates how much the Slope ſhall be, and is called the *Inward Talu*, as O Q is the *Outward Talu*, which is always ſo little as the nature of the Earth will endure. Some Earths will lye ſo cloſe and firm, that the Outward Talu A O may be very ſmall, but the Inward Talu commonly is made double the Slope of the Outward, that upon occaſion the Souldiers may aſcend to the top of it, and ſo that R S may be equal to S T the Heighth, that is, one Foot for a Foot riſing.

Upon the Plane of the top of the Rampire T Q, with the ſame Exterior Slope Q A, is built a *Breſtwork* or *Parapet* L Z P Q, and this is made of a Man's heighth, and ſurrounds the Fort; to which is added a *Foot-bank* V X Y L to ſtep up upon. This Breſt-work has its greateſt thickneſs L Q, the thickneſs at the top *p P*, its height P N or *p D*, his Outward Slope P Q, and its Inward Slope Z L, and the ſtep of the Breſt-work V X Y.

The Plane or Walk of the Rampire T V, called *Terreplane*.

If the Horizontal Level-line R A be continued

nued out at length towards the *Campaigne*, then is A E the Foreland, Barm or Lizier, to the Rampire betwixt that and the Ditch; but if there were no ſuch Foreland at all, it would be much better and ſafer: for the Foreland gives the Enemy advantage to land on, or it gives hold to Ladders or other Engines to reſt on, for paſſing the Ditch, and running to the next advantageous place for climbing up the Outward Face of the Rampire, it hinders the Soldiers or Inhabitants within from eſcaping by ſlipping down to this Foreland; to prevent all which there ought to be no ſuch Foreland, but to bring a Stone Wall well wrought from the bottom of the Mote to the Rampire, in the manner as A L, either a little battering or near an upright. But if the Money appointed for the making of the Work fall ſhort of the Eſtimate including this Stone Wall about, then you muſt leave a Foreland to ſuſtain the weight of the Rampire proportionable thereunto, the leſs the better.

The great *Ditch* or *Mote* that ſurrounds the Fort, is repreſented under the Level-line by E F H G, which muſt be made wider than the longeſt Trees that can be gotten, to prevent laying over Timbers or Ladders for paſſing it. E F is the Inward Slope or Scarp, H G the outward or Counter-ſcarp, I F or K H the Depth of it. And if it be a dry Mote, or a Mote not very full of Water, then in the middle of the bottom of the Mote there is made a little Ditch

as

as large and as deep as the Work and Earth will give leave, which is here represented by *e q g*.

Next to the *Mote*, if it be full of Water upon the Level-plane *G C*, is left another Foreland called the *Covert-way*, and before that towards the Campaigne is raised a Brest-work or Parapet with a Foot-bank; the Parapet must be a Man's height, and must slope easily into the Campaigne to *d*.

Lastly, this *Orthographical Section* or *Profile*, is cut or placed at right Angles through the Face, for through the Curtain it would be another Section, because that the Mote is not so posited at that place. Thus much for the Explanation of the Terms.

§. 2. *Of the Dimensions and Measures of Rampires, Parapets, Ditch, Covert-way, or Brest-work.*

The *Rampire*'s Thickness and Height must receive its Determination from the Judgment of the Ingineer and Purse of the Prince; for according as the Ground may prove, whether near a Quarry of Stone, where little Earth may be had but Stone most, or where there is a deep Soile, or as the Works may require to plant many Cannons and great Guns upon the Rampire, or as Money will be found to finish withall, so must the Bigness and Substantialness of your Works be. Therefore to give Rules for the thickness of the Works, or according to the nature

nature of the Polygon (as ſome do) would be needleſs, I ſhall give you the higheſt that needs be made, and the leaſt, and teach you how to proportion any mean meaſure from thoſe two.

The *Height* T S may not exceed 18 Feet or be leſs than Ten; to be higher would bring great Inconvenience for defending the Ditch or near approaches; to be lower, not convenient either for the eaſie Aſcent, or for Cover to the Buildings.

The *Thickneſs* of the Rampire R A may be from eighty to fifty Feet for all Royal Works, and according as Earth is to be had; it is reaſonable that ſpacious Works of many Angles ſhould have the thickeſt Rampires; and ſometime for Defence of a River, or to fortifie a Paſs in a ſmall Work, the greateſt is required alſo; therefore to ſet down poſitively the Thickneſs is but to do it by Gueſs, and cannot be exact.

The *Slope* of the Inward ſide of the Rampire T R, is commonly a Foot for a Foot, therefore R S the Talu will be equal to the Height T S, if T S be 18 Feet, R S will be 18, if it be 15 then 15, if 10 then 10.

The *Outward Slope* Q A cannot poſitively be given, becauſe ſome Earth will ſtand better than other; the general Proportion is $\frac{1}{2}$ a Foot for a Foot, that is, if the Height O Q be 18 Feet, then the Talu O A will be 9, if 10 then 5 Feet, the leſs the Slope the better, but moſt times the Rampire will not ſtand at that pro-

proportion without you line it with Brush-wood and Faggots. Experience must be the Guide.

The upper Thickness of the Rampire T Q is equal to the lower Thickness less by the two Talues R S and O A; if it was as before 80 Foot thick at the bottom, and the Talues 18 Foot and 9 Foot, then the top would be 53 Feet. If the Rampire be faced with Stone or Brick, then the Thickness may be abated accordingly.

The *Breſt-work* or *Parapet*, which ſtands upon the outward Edge of the Rampire, muſt alwayes be 6 Foot high, that is Z D muſt be 6 Foot, the Outward Height P N muſt be 4 Foot to give a Slope to defend the Counter-Scarp and the Field further on. The Thickneſs of this Parapet at the Top *p P* ſhould be Cannon-proof, and therefore alterable according to the nature of the Soyl; in light Earth it may be 20 Foot, in ſtiffer 16, and in very ſolid rough Clay 14 Feet. Suppoſe you take it 18 Feet, and allowing the Slope half a Foot in a Foot, P N will be 4 Feet, and N Q 2 Feet. The Inner Talu L D will need never to be but 1 Foot, becauſe of the Foot-bank that ſupports it, and that thereby the Muſqueteers may ſtand up cloſe to it, and therefore the lower Thickneſs of the Parapet L Q will be 21 Feet.

Fig. 25.

The *Foot-ſtep* or *Banquet* that Muſqueteers ſtand on for Service is U X Y, and is 3 Foot thick for V L, and a Foot and a half high for V X.

The

The *Foreland*, *Barm* or *Lizier* (if any be) must be made so wide, as to support the Rampire from slipping into the Ditch, and is taken from 3 Feet to 8 or 10.

The *Mote* or *Ditch*, whether dry or wet, must be made 70 Foot wide at the least, (for a wideness under that is not safe, for that the Enemy may lay Booms, Beams, or Rafters joyn'd (if need be) to lay over it to pass by, it may be wide from 70 Feet to 130 or above, that is, for E G, and it may be 8, 10, or 12 Feet deep I F. But because the Earth that comes out of this Mote must not exceed much the Solidity of the Earth that must make up the Rampire, Parapet of that, and Covert-way, the true wideness and depth of the Mote will be then set down, when you shall know the Solidity of those, the true finding whereof, and the judgment in giving direction for the best building of the Works, is certainly the best Quality in an Ingineer; and he that can best mannage this part, and can by his Providence proceed to save his Princes Purse, is to be preferred before any whifling Pretenders to the meer Theory and Paper-part of Fortifications.

The *Covert-way*, or passage between the outward Slope or Counter-Scarp of the Mote, and the Brest-work, is left about 18 Foot wide, or a little more or less G C, upon which is to be a Brest-work or Parapet of the same height, and with the same Foot-Bank that the Rampire had on the inside: but this Parapet has this difference,

ference, that it ought to slope into the Campaigne, so that a streight Line drawn from the top of the Rampire Z, may terminate the Slope *C f d*.

Lastly, to practise and lay down this *Profile* according to this Table.

	Feet.
Base of the Rampert R A	70
The Heighth T S *or* Q O	16
The Inward Talu R S	16
The Outward O A	8
Base of the Parapet L Q	21
Inward Height Z D	6
The Outward Height N P	4
The Outward Talu N Q	2
The Inward Q D	1
Bredth of the Foot-bank V L	3
Height of it V X	1½
The way on the Rampire or Terra plana T V	25
The Fore-land or Barm A E	3
The Bredth of the Mote E G	112
The Depth of it I F	12
The Breadth at the bottom F H	88
The two Talus E I, *or* K G *either*	12
The little Ditch at the Top	18
The Depth of it	5
The Covert-way G C	18
The Seat of the Parapet C d	60
The heighth of C f	6

Draw

Draw a Line long enough R S O A E I K G *c d* for the Level or Ground-line, and take a Scale of 20 in an Inch, or 30 at moſt, which ſhall repreſent Feet. And from that Scale take 70 for R A, 16 for R S, 8 for O A, 3 for A E, 112 for E G, 18 for *G c*, and 60 for *c d*, and mark them upon the Paper (as in the *Figure* 25.) at S. O. I. K. C raiſe or let fall Perpendiculars, and from the Scale take 16 for S T and O Q, 12 for I F and K H, and 6 for *C f*, and draw the lines R T, T Q, Q A, E F, H G, *c f*, and *f d*: laſtly, from Q ſet off Q L 21, L V 3, Q N 2, and L D 1, and raiſe the Perpendiculars N P 4, D Z 6, and V X 1½, draw the Line V X, X Y, Y Z, Z P and P Q, and make the little Ditch *e q g* by its meaſure, ſo have you the Profile perfected. As for a *Fauſe-Bray*, the making of them being found inconvenient, I mention it not. Fig. 25.

§. 3. *Rules how to caſt up the* Solidity of the Rampire, *and its* Parapet, *together with the Parapet of the Covert way beyond the Counter-ſcarp, and to proportion thereby the Wideneſs and Depth of the Mote or Ditch, that ſufficient of Earth may be gotten out of the ſame.*

The Example is of an *Hexagonal Fort* or Fort of ſix Bulwarks or Baſtions, whoſe Inward Polygon ſhall be 720 *Engliſh* Feet, and according

to *De la Adonts* way before ſet down, the Gorge Line to be $\frac{1}{5}$ part of it, *viz.* 144 Feet, the Flank the ſame, and the Capital $\frac{1}{3}$, *viz.* 240. The Curtain will be 432, and half of it 216. The height of the Rampire 16 Feet, the Inward Talu 16 Feet, and the Outward 8 Feet. With theſe Numbers upon a large Royal Sheet of Paper, with a Scale of 20 Diviſions or Feet in an Inch, I lay down the 12th part of the Rampire from the middle of the Curtain to the Point of the next Baſtion, as followeth.

Fig. 26. Firſt, I draw a Line at length *p c A*, from my Scale of 20 Feet in an Inch, I take the Gorge-Line 144, and ſet it from *p* to *c*, and 216 the half of the Curtain from *c* to *A*; upon *c*, I raiſe a Perpendicular *c f*, and take 144 from my Scale, and ſet it from *c* to *f* for the Flank; then upon *p* upon the Line *p c A*, I raiſe an Angle of 120 degrees, (being the Complement of 60 degrees to 180) becauſe my Fort is an Hexagon, and draw the Line *p a* for the Capital, and take from my Scale 240 for the Capital, and prick it from *p* to *a*: then I draw *a f* for the Face, *f c* for the Flank, and *c f* for half the Curtain, and make a Perpendicular at A B. After this I take from my Scale 70 Feet for the Wideneſs of the Rampire, and draw it by B parallel to the former Line B D L K M Y for the ſeat of the Rampire; I continue *f c* to D, and need none of the Lines betwixt *c D* and A B, they being all equal to 216 Feet. Then within the ſeat of the Rampire I draw *K i n p o x w* at the diſtance

of

of 16 Feet, taken from the Scale equal to the Inward Talu, and *degrt* at the diſtance of 8 Feet for the Outward Talu. The Earth or Solidity that lyes betwixt theſe two Lines is a Parallepipedon all of one height and thickneſs, and the Content is gotten by multiplying the Superficies at the Bottom by the Height of the Rampire. The Earth that lies on either ſide of this Body, and has each Talu for its Baſe, and ends at the Top of the Rampire in a Line, are Priſmes or half of Parallepipedons, and the Solidity is gotten by multiplying the Superficies at the bottom by half the height of the Rampire. There yet remains four Quadrangles *LKIh*, *cdeg*, *mnop*, and *rsfq*, and two Triangles *avt* and *wxy*; three of theſe, *viz.* *LKih*, and *rsfq* and *avt* lye to the outſide of the Rampire, and have one or two Sides to be ſeen, but the other three lye with all their Sides hidden in the Rampire. The Solidity of the firſt ſort being erect Pyramids, is gotten by multiplying the Baſe into $\frac{1}{3}$ of the Height; the ſecond ſort, being Pyramids jacent, is gotten by multiplying the Baſe by $\frac{1}{3}$ of the Height. Having given the Rule, now we ſhall apply it to the Example aforeſaid; and firſt I draw a Line in the middeſt between the two Talu-lines, and find the half length of the Curtain 216, more by 8, more by 23, more by 23 more by 8, more by 119, more by $220\frac{1}{4}$, (I give the ſeveral Lengths that you may ſee the Practice;) all which makes $617\frac{1}{4}$ Feet, which multiplied

by 46 the Wideneſs, gives 28393 ſuperficial Feet for the Plane at the Bottom, and that multiplied by 16 the Height of the Rampire, gives 454288 the ſolid Content in Feet. Next for the two Slopes the Length of the Outward, I find by the Scale to be 611½ Feet, which multiplied into 8 the Baſe, gives 4892; and the Inward Slope the Length to be 547½, which into 16 gives 8760, both which Baſes 4892 and 8760 makes 13652 Feet, and that multiplied into 8 (half of the Height) gives 109210. Now for the two Quadrangles, and one Triangle, that lies to the Outſide of the Rampire. The firſt *Lhik* the Sides are 16, and 16 into 16 gives 256: the ſecond is *rsfq*, I take the length of *rf* upon my Scale, and find it to be 10 Feet, and take the Perpendicular from *q* or *s* to *rf*, and find it 6½ Feet; the Product of them will be 65, the Superficies of the Triangle *avt* is 36 Feet. All theſe three Planes 256, 65, 36, makes 357, which multiplied by ⅓ of the Height of the Rampire 5⅓, makes 1904. And for the two Quadrangles and Triangle, that lye within the Rampire, uſing the like means, I find *gcde* to be 64 Superficial Feet, *mnpo* 263, and the Triangle *YXw* 126, which make in all 454, which multiplied into 10⅔, the ⅔ of the Height gives 4842 ſolid Feet; all which Solids added, *viz.* 454288, 109210, 1904, 4842, makes in all 570244 ſolid Feet for the Content of the 12th part of the Rampire.

This

This way is Geometrical and very true, but the Workmen and Undertakers will not understand it, but use a Mechanical way, which for the Ease and neer approach to the Truth is not to be contemned, which is thus. Take the length of the outside of the Rampire for this 12th part, *viz.* the half Curtain 216, the Flank 144, and Face 274½, which makes 634½ Feet. The length of the Inside by the Scale or Measure will be found to be 596½ Feet, both added make 1231, the half 615½ Feet. Secondly, measure the Superficies of the Profile thus. The Bottom is 70, the Top 46, the Summe 116, the half is 58, which multiplied by 16, gives 928 for the Superficies of the *Profile*. Multiply the Length 615½ by 928, and the Product will be 571184 solid Feet for the Content of the $\frac{1}{12}$ part, differing from the true onely 940 solid Feet, which is not so considerable. Therefore this way as it is very easie, is most used; though I would have the Ingineer to use both, (lest some mistake may be made,) and thereby he may be assured of the truth.

Therefore let the Mechanical Rule generally used, either for the Rampert, Parapet or Mote be this. *Take the Length of both Sides, and adding them together take half as a mean, which multiply by the superficial Content of the Profile, the Product gives the Solidity.*

Thus the Solidity of the $\frac{1}{12}$ of the Rampire is found to be 571184 Feet. The middle length of the Parapet I measure by the Scale to

be 628 Feet for $\frac{1}{12}$ of the Parapet, the Superficies of the Profile of the Parapet $97\frac{1}{2}$, the Superficies of the Foot-bank $4\frac{1}{2}$, the whole Area 102, which multiplied by the Length 628, gives for the Product 64056 ſolid Feet.

Then for the Breſt-work beyond the Covert-way that is 6 Foot high, and has 60 Foot Talu to ſlope into the Campaigne marked by *C f d*. For to meaſure the middle Length I
Fig. 25. muſt not now work by the former Rule, but I muſt take the middle of the Superficies of the Triangle *C f d*, becauſe the other would be too long, (and this way ſhould have been obſerved in getting the middle of the Rampire, if you would have had the Superficies of the Rampire and Parapet together.) The Length of *C d* is 61, the Height is 6, the half 3, the Area 181, the Area of the Foot-bank is $4\frac{1}{2}$, as before. The whole $185\frac{1}{2}$, the half of 185 is $92\frac{1}{2}$, and if you cut off a Triangle at the end towards *d* of that Area, you will find the Line to cut it leſs than 20 Foot, *viz.* 19 from C at *g*. The length of the Line that goes parallel to this Point will be found to be 605 Feet for the 12th part of this Breſt-work, which multiplied by $185\frac{1}{4}$, the Area of the Profile as before, makes 111971 ſolid Feet, and adding the Solidity of the Rampire and theſe two Parapets together, the Summe of all is 647111 ſolid Feet, being $\frac{1}{12}$ of the whole. Now for the Mote it is reſolved it ſhall be 100 Feet wide.

The next buſineſs is to proportion the Depth

of

of the Mote to this Solidity. The way is to divide the Solidity 647111 of the Rampire, and two Parapets by 531 the middle Length of the Mote, (from the middle of the Curtain to the Capital Line extended) the Quotient will be 1218 ſuperficial Feet for the Profile of the Mote or the Section of it, (the Mote is like the Rampire in all things, turned upſide down as you may ſee by the *Fig.* (25) E G H F.) Laſtly, divide 1218 by the 100, the Quotient is 12 Foot and $\frac{18}{100}$ of a Foot for the Depth. But that will be too little; for if the Slope be one Foot in a Foot then at 12 Foot deep, the Top being 100 Feet, the Bottom 76, the middle 88 multiplied by 12 the Depth, maketh 1056, and that by 531 the Middle for the Length, gives 560736 ſhort of the Solidity it ſhould be: therefore widen the Mote 12 Foot more, and make it 112 Foot at the top, and then it will give you the true Solidity at 12 Foot deep. If the Ground will not endure to go ſo deep, then you muſt widen the Mote, ſo that you may have the aforeſaid Solidity. But I ſhall give you this Caveat, That the Earth that comes out of the Mote, when Rammed and Trimmed, will go into leſs room by neer $\frac{1}{12}$ part; and though the Solidity of the Gates, Paſſages, and Vaults in the Rampire will yeild the more Earth for the work, yet all that will not do, but you may add ſafely a 20th part of the whole to be ſure of Earth, as the 20th part of 647111 is 32355, which makes the $\frac{1}{12}$ of the Rampire

679466. For if you ſhould want Earth, then is the Remedy bad, you muſt fetch it beyond all the Works, which will be almoſt double the Charge; but if there ſhould be too much, that is no Inconvenience, for you will have occaſion enough for Batteries and other Works within the Fort.

But this Eſtimate being in ſolid Feet will want yet a Reduction to an higher Denomination. There has been ſome Hundreds of Thouſand Pounds expended in the great Level of Fens lying betwixt *Cambridg* and *Boſton*, and ſcarce any County in *England* but has had Men there, therefore the Cuſtome uſed there is fit ſtill to be continued, becauſe Undertakers of Work know beſt how to caſt up by their own uſual way; their *Gad* or meaſuring-Rod is nine Feet long, and two of them, *viz.* 18 Feet, is called a *Perch* or *Pole*, and that Squared, that is 18 Feet each way at right Angles, and one Foot deep, that is 324 ſolid Feet of Earth is termed a *Floor*, ſo that all their Eſtimates for Banks or Drains is judged by the Floor. If you therefore deſire to know how many Floors of Earth there will be in any piece of Work, caſt it up by Foot-meaſure, and divide the Solid Feet by 324, the Quotient is the Floors, and if the Remainder be 243 it is $\frac{3}{4}$, 162 is $\frac{1}{2}$, and 81 is $\frac{1}{4}$ of a Floor. So that in the former Solidity of the Rampire and Parapets 647111 Feet, there would be 1997 Floors of Earth $\frac{1}{4}$ and 2 Feet: and becauſe this is but the $\frac{1}{12}$ part of the whole

Fort,

Fort, there would be in the whole 23967 Floors, and 24 Feet. There is yet a Parcel of Ground left betwixt the Mote laſt meaſured and the Curtain, *viz.* that which is included by the Letters *c f A z*, in which place if there be a wet Mote, it will be fitting to leave part of a Faus-Bray or Tenail, whereon ſhall be a Parapet. Set off the ſame Height and Dimenſions of that on the Rampire, and place enough to plant Cannons and diſtance for their Reverſe; you may take 60 Feet from the Mote, *viz.* 3 Feet for the Fore-land, 21 Feet for the Seat of the Breſt-work, and 36 Feet for the Plane, and leave 30 for a Mote. Betwixt this Work and the Flanks, and the Earth that comes out here, will build the Breſt-work to it, and there will be to ſpare to be carried into the Fort for other uſes, the Solidity of it will be taken by the former Rules, but if it be thought good to take it all away, then you muſt exactly caſt it up, and conſider it as part of the Mote.

I have been very plain in this laſt Paragraph, becauſe it is of Conſequence; and it is of more uſe to a *Prince* to have an Ingineer that is knowing in the Meaſures of a Country, and in the Rates and Values of Works, than in one that can vapour, and talk of the Forms and Lines, and be ignorant otherwiſe: for one may lay down more Forts in an hour upon Paper, than all the *Chriſtian Princes* joyned together ſhall make in Ten years.

Now for the Solidity of Cavaleers, Plat-

forms,

forms, Mounts, and other Works, if you ſhall practice what I have writ before, it will be eaſie to do them, for the Cavaleers are round, and caſt up like a Cone cut off, the reſt like the Rampires and Parapets.

§ 4. *How to build up any Fort, and how to make an Eſtimate of the Coſts and Moneys that will be required to do the ſame.*

The Body or Maſs whereon the Fort is to be built may be conſidered three ways; either 1. As Rock and Stone; 2. As *Terra firma*, or good ſtrong Ground; or 3. As Ground upon the brink of Rivers, that has been raiſed by ſucceſs of Years, which the deeper it is, the more ſoft and falſe, till you come to ſome certain depth to the firm Ground again.

1. If it be a Rock, then leſs will ſerve for the Mote, and the Maſon that undertakes the building of the Walls will agree by the Great for railing and getting the Stone and Building of the Rampire, which he will agree for by the Rod of 16 ½ Feet, or 10 Feet every way, which is called a Square one Foot deep, and the Rates will be ſo incertain that you muſt be ruled by the Cuſtom of the Countrey where the Work is, whereof if you be not a ſtranger, you will be able to caſt the Walls and Motes up; if a ſtranger, then by enquiry how Work is

is let out by the Great, you may compute and value what the Work ſhall be worth doing.

2. If it be ſolid ſtrong Earth, then you will be better able to deal, and your Work will be ſubſtantial in its Foundation; if it be Work that will eaſily delve, and one may ſpit it up, it may be worth five or ſix ſhillings a Floor to dig it up, carry it out, and build up the Rampire and Parapets with it, and to face the outſide of the Works with Turf, which you are to cut with ſharp Spades in form of a Wedge, after the faſhion of *Fig.* 27. They may be ſix Inches or a little more in breadth, and near ſo much at the one end; they may be above a Foot long, near 15 or 16 Inches, and ending like a Wedge; theſe are to be laid with their thicker end to the Face of the Work, and filled up and rammed with the top ſpit Earth; the Work is to be raiſed Foot by Foot, all level, and the Workmen are not to be ſuffered to lay above one Foot and an half, 'till that be rammed with a good Rammer of 50 or 60 lb. weight, all horizontally level, and when that is finiſhed to lay another Layer of Earth of the like thickneſs, and ramming that, ſo by Foot and Foot till the Work be compleat. To bring up the Slope true, the Ingineer is to make the Workmen ſome Bevills ſloping, as the Slope of the Work ſhall be appointed, ſuch as the *Figure* 28. that laying the ſlope ſide to the Work, the Plummet may play down exactly upon its Line; or there may be ſet long ſtreight Poles

Fig. 27.

Fig. 28.

ſo

so sloping as the Work should rise, and supported each by another upright Pole, which may be left in the Work to guide the Work by, as the Workmen well know. The Work being 23967 Floors, at 6 *s.* a Floor, to finish and compleat all will come to 7190 *l.* but if it should prove Gravel, or part Stone, then the price of the Work may rise to two or three shillings in a Floor more.

3. If it should be mooriſh or marshy Ground, then you must have great care of the Foundations of the Rampire, for the weight of that will press the Foundation and make it raise the Mote, and then all will slip down (as was found both at *Sheerness* and *Tilbury*;) therefore to prevent this, the Foundation of the Rampire ought to be Piled, and a Frame of Timber fitted so as you see in the *Figures* 29, 30, 31. The *Figure* 29. shews you how the Piles were driven, which must go so deep, that a 16 hand Bell-Beetle will not at last drive above half an Inch at a stroke or less, if the bottom of the Pile come to touch the firm Ground. The Faces of the two half Bastions at *Sheerness* are thus ordered, A B represents the bottom of the Rampire towards the Mote, the Piles as you see in *Fig.* 29. marked O, are 5 Foot asunder, near 30 Foot long, and near a Foot Square at the Head; at the distance of some 12 or 14 Foot of these, there are as many Piles driven between E and F, answering the former; upon each two of which, there is strong Land-

tyes,

tyes, one of 45 Foot and another of 30 Foot, wrought into the Heads of the Piles, with Anchors at each Land-tye, and two Piles to hinder that the Work ſhould not draw towards the Mote; the Piles and Land-tyes both in A B and E F are covered with a Liſt of above a Foot Square, and betwixt each Land-tye are 3 or 4 Piles driven here and there, that have Heads above the Plane of the reſt 4, 5 or 6 Feet, that ſtands within the Rampire amongſt the Earth; and if it be reſolved to Face this Work with Stone or Brick, then you muſt Plank ſo much of the Forepart with 2 ½ Inch Plank, and ſo deep as you intend the Seat of the Wall ſhould go; this was done at *Sheerneſs*, the Face having ſlid into the Mote; and though it be a great Charge, yet the Inconveniences for want of it will be more, and cauſe greater Layings-out: For at *Gillingham* it was thought, that laying a double Floor under the Brick-Redoubt, with very ſtrong Timbers croſs bound, and 3 Inch Plank on both Floors, yet for all this, when the Brick Building was raiſed and finiſhed, it being 30 Foot Square, 7 Foot thick, and near 30 Foot high, it began to give way, and hung over on one ſide by degrees 25 or 26 Inches, and certainly would have fallen quite down, if by good Fortune we had not adviſed and reſolved to undermine the Redoubt on the contrary ſide, by digging a 10 Foot Dike by it, and under ſome part of it, by which means it came back again, and when near

Fig. 30.

Fig. 31.

near to the Perpendicular, the Dike was fill'd and ramm'd with Chalk, and the Work has ſtood ſo this three years without any alteration; all which danger might have been ſaved by driving down Piles to have ſupported the Foundations.

As for the Mote you muſt give it a Slope, as you ſhall be adviſed will ſtand without ſlipping in, and the Earth muſt be carried up in Wheel barrows, as was ſhewed before; this will not coſt above 5 *s.* a Floor to carry out and trim upon the Rampire, and it will be in vain upon Salt Marſh-ground to face the Bank with Turf, for it will not grow, but will after ſome Winters freſh Rains grow of it ſelf. To complete the Eſtimate of the Fort, care muſt be taken to value the Buildings of what nature ſoever, which requires the Ingineer to be ſomewhat skill'd that way, that his Eſtimate may reach in ſome meaſure to finiſh the Work; for which end there are many Books lately printed will help him, and to which I refer my Reader; for it would be a longer work than I intend, if I ſhould go to each particular that would be required, for the making ſuch an Eſtimate complete.

§. 5

§ 5. *To know how long a Work will be in finiſhing, how many men muſt work to do it in the time preſcribed, and the manner to be obſerved in working.*

In Earth that will abide Spitting, one man will fill into Wheel-Barrows a Floor and half of Earth, and it will require three men to carry it, and place it in the Rampire, (one Place and Height with another,) and for every 10 Floors it will employ a ſufficient Rammer to trim and ram the Earth. Therefore our laſt mentioned Fort, containing 23967 Floors, will be finiſh'd in Eight Months by 350; but this imagines every day fair, and all able ſtout men. You may therefore rely on 500, and leſs will not do, neither will it be done in this time if it be not let out by the Great. This way may give ſome light, but becauſe all Earth differs, Prices and other Accidents alter, it will be impoſſible to give a general Rule; and upon the place the Ingineer may make ſome Tryals, which may help likewiſe to the Eſtimate-making. You ſee therefore how neceſſary it is, this Perſon ſhould not only be expert in the Deſigning part, but much more in the Mechanical; he ought not only to know what belongs to Earth-work, but to the Maſons, Carpenters, Joyners, Plumbers, and to the prices of Timber, Lime, Sand, Brick, and all other Materials; and all this in ſuch manner that he may not be overſeen, or aver

things

things to the Commiſſioners that are employed, for which he may deſerve blame.

Sometimes when the Earth is ſandy, there will require great ſtore of Faggots and Bruſh-wood to lay in the Work; but I have been too tedious about this part already, and will now leave it to the Ingineers Practice.

§ 6. *Works that are uſually made within the Forts, as Platforms, Cavaleers or Mounts, and Cazemats in the Flanks; and Works out of the Forts, as Ravelins, Horn and Crown-Works, and the like.*

1. Of *Platforms.* Theſe are the Plantations where Guns are to be placed, and are commonly made of Plank and Sleepers to lay them on; there needs not for one Gun to be but one Platform, unleſs Timber and Plank be reaſonably to be had, then you may make whole Platforms throughout, for ſo many Guns as you intend to plant together: As for a ſingle Platform, next the Port-hole it need not be above 8 Foot wide, and the further end 14, the length ought to be 18 Foot at the leaſt; the Parapet muſt be opened for the Port-hole, and need not towards the Gun be above 4 Foot wide, and towards the Campaign or Enemy 8 wide, this is called an Embraſure; they are generally no more than 20, 18, or 16 Foot aſunder from

midſt

midſt of Port to midſt of the Port: But if the Guns be to Play clear over, without any Ports, the Breſtwork muſt be abated to 2 ½ or 3 Foot high, as the Wheel of the Carriage will be high, and inſtead of Earth you muſt have Cannon Baskets and Earth ready by, to fill, ſet, and remove, as you ſhall have occaſion.

If the Terraplane, or Walk of the Ramperts will not be 20, or 22, or 24 Foot wide, then on the Fort ſide you may by a Frame of Wood brought up from the Ground enlarge the ſame as you ſhall ſee convenient.

2. *Cavaleers* or *Mounts*, are maſſie pieces of Earth, raiſed on or near the Ramperts above the Parapet, whereon to plant Ordnance and Small Shot, and are of great uſe to hinder the Enemies Approaches, and to clear the Faces, and diſturb the Batteries of the Enemy.

I follow the Directions of *Maneſſon*, who places them in the Gorge of the Baſtion, and gives this Rule for the Center, *viz.* Lengthen out the Line of Defence to E, till it cut the Capital, the Center of your Cavaleer ſhall be the middle Point betwixt *p* and E at F, with the diſtance of 84 Feet upon the Center F make a Circle, which ſhall be the Baſe of your Cavaleer, and becauſe the Slope, if it be of Earth, will be conſiderable, it being to riſe ſolid for at leaſt 20 Foot high, therefore face the Work with Brick or Stone, whether ſhall be cheapeſt, and then the Talu ſhall not need to be above a Yard and 4 Inches, or a Yard and 6 Inches, Fig. 32.

that is, 5 Foot and 6 Inches, which will make it above broad in the Diameter 160 Foot, whereupon ſet a Breſtwork of 20 Seat and high, and other Dimenſions as aboveſaid in the Rampire, and there will be a Terraplane at the top of above 100 Feet, whereon you may plant ſix Peeces of Ordnance, or as many as you can, leaving Ports or Embraſures in the Parapet, and making Platforms as was laſt directed.

3. *Cazemats*, or ſeveral Platforms for Guns, to be made in the Corner of the Flank, to be hid conveniently from the Enemies Batteries, and ſo to be preſerved, if poſſible, againſt the Enemy ſhall begin to lay his Galleries and paſs over the Mote, or to plant their Guns upon the Counterſcarp over againſt the Cazemat for the making of them. I follow *Maneſſon*'s Direction, *viz.* firſt, the Form; ſecondly, the Meaſure. The Cazemat ſhall take up one half of the Flank, and no more; the lower Battery, which is called the Grand Cazemat, B, is about 7 or 8 Foot, or 9 Foot, from the Level of the Plane of the Fort, and has a Ladder or paſſage into it from within the Fort A, C is the Parapet to it of 20 or 22 Foot Seat, and has 3 or 4 Embraſures in it; D is that part of the Grand Cazemat which is moſt hid from the Enemy; F is the Magazine for this Battery; H is the ſecond Cazemat or Platform, much hid from the Enemy; G the Ladder, and L the Magazine, and I the Parapet, this is to hold

but

but one Gun; M is the third Platform upon the Level of the Bastion, which is by *Manesson* all firm, having no void within the Bastion. 2. The Dimensions and Description are thus: Lengthen the Line of Defence from *c* to G some 40 Foot, draw G D parallel to *c f*, let C F be half of *c f*, that *c F* may be equal to *F f*, from the middle of the opposite Face, draw the Line K F and let it cut G D in *i*, that you make *i L* and F M 6 Feet, and M N 66 Feet, and make *N o* parallel to the Flank, and let *N o* be 24 Feet: Lastly, for the *Orillon* or Blind, prolong the Face *f T* 36 Feet, and F V likewise 36 Feet, joyn T V, and make that part all solid: So have you your Cazemat all made: For the Height of the lower Cazemat, make it 6 Foot as before, and the rest as in the *Figure*. Fig. 32.

4. Now we come to the Outworks, and first of the *Ravelin*, which sometimes is called the *Half-Moon*, is a certain Work lying beyond the Ditch for the Covering the Curtain, Bridge and Gate, and is often used in most Works both at home and abroad; it is like the Point of the Bastion with the Faces cut off, as you may see in the *Figure*, and the Angle of the Ravelin A is not to be under 60, nor above 100 degrees; the making of it is thus, Lengthen out the middle Line of the Curtain *o m* at length, take with your Compasses the Length of the Curtain *c c* and setting one Foot in *f*, the Point of the Flank and Face, cross the middle

Line at *q*, laying your Ruler at *q*, and to the
Fig. 33. ſaid Points *f* of either Face draw the Lines of the Ravelin *q r* and *q s*, which ſhall be the out Ground-line of the Ravelin: The Mote about this may be half the Wideneſs of the great Mote, the Height of the Rampert may be 30 Feet thick, and ſome 6, 7, or 8 Foot high, and thereon may ſtand a Parapet equal with that of the Rampire, the Point *q* may be taken a little further, and the Sides may ſtand out, if it ſhall be thought good to take in ſome part of the Face: The *Profile* and Meaſures of this are to be made after the ſame manner as thoſe of the Rampire. For the Half-Moons before the Points of the Baſtion, now out of uſe, I deſcribe them not. Note, that the Covert-way and Parapet, muſt include the aforeſaid Ravelin, as you may ſee in the *Figure*: If from the Points of the Flank and Face *f*, you raiſe Lines into the Campaign at Right Angles to the Curtain, and from the Points *f f* ſet off *f E*, *f F* 720 or 750 Foot, then may you joyn E and F either with *a*.

5. *Single Tenail*, which is done by joyning E F and dividing it into 4 parts, taking one, ſet it on the Line *o m M* continued to *N* draw
Fig. 34. E N, F N, the Lines I E N F L are the Lines of the Tenail, which is to have a Ditch, Rampire and Parapet, as in the laſt of the Ravelin, or leſs as occaſion ſhall require.

6. For a *Horn-Work*, if you joyn theſe Points E and F, and fortifie the Exterior Polygon

lygon E F by any of the Rules before taught; or divide E F into 3 parts, one whereof ſhall be E M or F N, draw M N and divide it likewiſe into the ſame equal parts at O and P, draw F O and E P at O and P, raiſe Perpendiculars or Angles of 98 according to *Maneſſon*, E Q O P R F ſhall be the Horn-Work deſired, and all the Works muſt have ſmall Rampires and Breſtworks made, as in the Ravelin beforementioned. Fig. 35.

7. For *Crown Works*, Draw out the middle Line from the Center O by *m* at length, and you may ſet off from the middle of the Ravelin 800 or 1000 Foot to B, making the Point *q* your Center, with *q B* ſtrike an Arch D B E, ſet off the Curtain and Demi-Gorge *p c c* from B to F and G both ways; ſo have you the Outward Polygons of the Crown-Work: draw Lines from F and G to *c*, the Points of the Curtains and Flanks, to terminate the Points I and H upon the Counterſcarp, and draw G I and F H, take $\frac{1}{3}$ part of B F or B G, and ſet it from B to M, from G to N, and from F to L; L M, M N are your Interior Polygons. For the Demi-Baſtion, make N P and L O equal to N G or F L; and for the Demi-Gorges of the whole Baſtion in the middle, let them be $\frac{1}{5}$ of the Interior Polygon M N or M L, *viz.* M Y or M X, finiſh the Baſtions, by drawing the Lines of Defence, and raiſing Perpendiculars, or making Angles of 98° at O X Y P. You may make Ravelins Fig. 36.

before the Curtains, if it be needful, or advance Horn-Works or Tenails forwards, if there be Hills or rising Grounds, or if you will meet an Enemy that is coming to Besiege you; for the greatest use of these foregoing Works are to advance forward into the Campaign, to hinder the sudden Approaches of the Enemy, and to spend his time before he shall come to the Main Works.

Some other Works are made (which joyn to the Counterscarp) as Bonnets, Double Tenails, and others, which I have no need to speak of in this Treatise.

8. The Outworks that lastly are used without, are Cittadels, Castles, or Forts of the least sort, which are built to Bridle the Town or Place, lest the Burgers should be rebellious, and to be the last Refuge or Place of Retreat: They are commonly of 4 or 5 Bastions, and no more, and are set so that there may be two Faces and a Curtain towards the Town; the Center of the Cittadel may be found in the middle Line O M drawn out at length, the Inward Polygon of the Pentagon may be $\frac{1}{4}$ of the Curtain adjoyning, or a little more; the very Center of the Square may be upon the Point of the Interior Polygon *p*, the Center of the Pentagon may be near upon the Outward Point of the Bastion of the Town, taken away to make the Citadel in: All the Lines are drawn by any of the ways shewed for great Works, the Motes and other Works in proportion accordingly,

dingly, and the Rampires as high as thoſe of the Town: Peruſe *Figure* 37. and there you will ſee diſcribed theſe Works, which will better make you underſtand what has been written.

§ 7. *To deſcribe upon Paper by way of Perſpective the aforeſaid Works, or ſo much thereof as you deſire.*

The common Perſpective, that deſigns by a Point Principal, from whence all Parallels to the Principal Line do meet in that Point, is a troubleſome way, and doth ſo diſtract the Body of the Work, that unleſs one be skill'd in that kind of Perſpective, he is not able to know what it means; it is true, the Ingineer ought to be skill'd that way, becauſe ſometimes to repreſent ſome Body near at hand, or ſome Engin, it will be needful, and to that end *Le Boſſee* in *French* has writ well, and Perſpective Practique more at large, part being Tranſlated and Printed in *Engliſh*; but for deſcribing of Forts, Towns, *&c.* there is another kind of Perſpective, called *Perſpective Cavaleer*, that imagines the Eye at an infinite diſtance, that is, at ſuch a diſtance, that all equal Heights in the Fort are ſeen under one Angle, whether further or nearer, and all other Heights proportionable, and all Lines which would meet at the Eye are parallel, becauſe of the diſtance (as we ſay the Rays of the Sun falling upon a Burning-

Glaſs are parallel;) and after this way of Perſpective the Sphere is projected *in plano* called the *Analemma*, the manner ſet down by *Roias*, this therefore is not a Mechanical way, but founded on good Laws and Grounds.

Draw the Lines of your Fort with white lines, or with any thing that will rub out, with all the Parapets, Rampires, and Out-works. Then conſidering what Side you deſire towards you, whether the Curtain or Point of a Baſtion, or what other Point, draw a long principal line facing that Point, if it be the Curtain that ſhall be towards you then draw the line parallel to it, as in the Example A B. Having a Square run the ſide of it upon A B, and beginning at the extreme Points of the Ravelin, Baſtions, Flanks, Eſpauls, draw Perpendiculars towards that Line throughout, omitting thoſe that will cut the Rampire or Parapet; and theſe Perpendiculars muſt be drawn likewiſe from the Inward Angles within the Fort. Having drawn theſe, take what Height you pleaſe, that will beſt repreſent the Heights of the Rampires deſired. Suppoſe you take half of the Flank *c d* for a Rule, ſet this off on each Perpendicular before drawn, towards the Principal, as in the Example from all the *c*s, all the *f*s, all the *a*s, *&c.* from which Points draw Parallels to each reſpective Curtain, Face, Flank, Rampire in the Inſide, as you ſee in the Example, and finiſh all as you ſee in one half of the Figure of an Hexagon complete.

Fig. 37.

CHAP.

CHAP. V.

Of Irregular Fortifications.

§ 1. *Such Figures that have not their Sides and Angles equal one to another are called* Irregular, *as the Forms of Towns to be fortified commonly are; before any Judgment can be made, it is requiſite that the Ingineer make a Map or Plot of the whole, with all the Ways, Paſſages, Old Walls, (if there be any) Rivers, Pools, Encloſures, and all other matters fit to be known in the Draught, and then he is to deſign what works he ſhall think moſt agreeing to the place to be made; to this end let him know,*

1. THat the ſame Laws and Maxims for Regular Fortifications ſtand and be in force as for Irregular, that is the Lines of Defence muſt not exceed the Port of a Muſquet, nor the Angles of the Baſtions be leſs than 60 or much above 90°, and the reſt.

2. That no Angle of his Figure (that is the Inward Angles of his Plat) be leſs than 90 degrees; if he find them leſs, they muſt be changed,

ged, and that Point may be made the Outward Point of a Baſtion.

3. That all the difference betwixt Regular and Irregular conſiſts in the rectifying the Sides that are too ſhort or too long, and altering the Angles that are too little.

For the *Sides*, if they be 500 Foot or above, and under 1000, they may be fortified by Baſtions, ſet on each Point as in the ordinary way; but if the Sides be above 1000, and ſo upwards to 1500, 1600, or 1700 Feet, then you may ſet a whole Baſtion on the middle of the Line, and Baſtions on the extreme Points of the Line, which are Points of the Polygons; but if the Line be leſs than 500 Feet, then by lengthning it into the Plane you may make it the longer, as you will better underſtand by the Example, taking by the Scale with your Compaſſes the length of the Lines, you will find by the prickt Line what is taken in or left out. Much after the ſame manner you may ſee by the Example when the Angles were too little how they are to be enlarged: there being ſo much variety in this buſineſs the Ingineer muſt practice by himſelf, by drawing ſeveral Plats of Irregular places and fortifying them, and becauſe Examples in this matter exceed all Precepts, he muſt peruſe all the Books he can get of this buſineſs, *Marlois*, *Fritach*, *Dogen*, and others, but above all *Dilichius* in his *Piribologia* he may find infinite Examples, that will much help him, and will inform both his Judgment and Diſcretion for

for effecting his desire. For the raising the Rampert, and the Parapets, and other measures, they are to be as in the Regular, and no otherwise, and you may place all or any of the Out-works before mentioned before the Curtain, as was before set down; and there is much a greater Latitude for the raising of Out-works, left to the Discretion of the Ingineer in this than in the Regular, as you may find by the Terms and Examples following.

1. A is a *Regular Bastion*, wherein to find the Capital Line *p a*. Divide the Angle at *p* into two equal parts by *p o*, and draw out *o p* to *a*, that shall be the Capital, (which is to be observed as a Rule to find the Capitals in all Irregular Angles.) This Capital *p a* may be 240 Feet, or a little more or less, for now we are not tied to few Feet, and the Gorges may be 144, or so to 150, or thereabouts. Fig. 38.

2. B is a *Double Bastion*, that is no other then upon the Plane of the great Bastion another Bastion built higher, there may be some 12 or 18 Feet left betwixt the Parapet of the lower and the foot of the higher Bastion. This has the use of a Cavaleer, and overlooks the Campaigne, and thereby the Faces opposite to it are doubly fortified.

3. When the two Interior Polygons are much unequal, then the Gorges will be unequal, and then the Bastion C is called a *Bastion Compesed.* Fig. 38.

4. If one of the Interior Polygons be so very

very short, that you allow it no Demi-Gorge as the Bastion D, then is is call'd a *Bastion Deform'd.*

5. If the Distance from the Points of the Interior Polygon be double to the usual Length, then in the middest you make a Bastion by the former Rules, which is called a *Plat-Bastion* E.

Fig. 38. 6. If the Angle of the Figure at *p* be less than 90 degrees, and because of some Accident of Water or other it cannot be changed, then you may cut off the Angle, and joynt it with a Tenail, as you see *Fig.* F, and it is called a *Bastion cut off with a Tenail.*

7. *A Bastion cut off*, or, as the *French* call them, *Bastion de tache*, are such whose Gorges are in a right line with the two Points of the Flanks *f*, and are made like Plat-Bastions last named, marked with G.

8. A *Demi-Bastion* H are such that have their Gorge and Capital equal, about 150
Fig. 38. Foot, and their Flanks half of the Gorge.

9. Upon an Inward Angle, if it cannot be changed, you may place a Plat-form I, that great Guns being there placed may scoure the Mote both ways.

10. If before any Point of a Polygon there be Marishes or drowned Grounds, then a little before the Point you may raise a round Figure, called a *Mount*, upon Piles, or made with Faggots and Earth as at K, the bigness to hold a *Corps de Guard*, with a Parapet, like as that of the Out-works, Cannon-proof; this is used to hinder

hinder Surprizes when the Water is frozen.

11. An *Indented Line*, is often uſed upon the Bank of the Counterſcarp, or upon a River or Sea ſide, or upon the main Land, as here at L it has a dead Angle, and laid aſide but upon neceſſity. Fig. 38.

12. A *Counter-Guard* is like M, which is a Demi-Baſtion built in ſome watery place before the Main-Baſtion.

13. And ſo if there be left in the Mote a Tenail N, with a Breſtwork, it is called likewiſe a *Counter-Guard*.

14. A *Bonnet*, O is an advanc'd Work like a Ravelin, it is ſometimes made on an high place, ſometimes on low ground, but always cut off and placed beyond the Counterſcarp.

15. For an Example of an Irregular Fort, I preſent you with the Draught of the Fort of *Sheerneſs* near *Quinborough* in *Kent*, made by Direction of His Majeſty *Car.* II. and His Royal Highneſs, and of that Conſequence, being placed upon a Point of Ground at the Mouth of the River *Medway*, which it Commands, that Men of Knowledge do admire the happy Foreſight of His Majeſty for the Direction, and that now his Royal Highneſs has begun to make Docks and Ways to Grave Ships in, and the Officers of the Navy has begun to ſettle Officers there, and to build a Yard and Store-houſes within the Fort; the next Age will ſee it a goodly and ſtately Place, when as even now it is very compleat.

§ 2. *Of*

§ 2. *Of small Forts or Skonces, which are built for Defence of some Pass, River, or other place.*

If they be to be made Regular, of four, five, or six Bastions, you may use the Rules before-going, which are sufficiently plain, but there are others of a smaller Dimension fit for Passes or Rivers, and likewise for the Field, which are:

1. *Triangle with half Bastions*, which may be all of equal Sides, or they may be some-
Fig. 39. thing unequal; however it be, divide the Sides of the Triangle into three parts, one of those three parts will set off the Capitals *p a*, and the Gorges *p c*, and the Flanks *c f* being at Right Angles with the Side, make half of the Gorge, as in the *Figure*.

2. *Square with half Bastions*, whose Sides may be betwixt 100 and 200 Feet, divide each Side into three parts as before in the Triangle, and set off one third from *p* to *a* for the Capital,
Fig. 40. and from *p* to *c* for the Gorges, but the Flanks (which raise at Right Angles to the Side) must be but half of the Gorge or Capital, that is, one sixth part of the Side of the Square. See the *Figure*.

3. *Square with half Bastions and Tong*; see
Fig. 41. the Figure. The half Bastions are made as before, for the Tenail or Tong, from the middle of the Square *m* set off one third of the Side

Side to G and H, and upon the Perpendiculars from *m* to M, and draw all as in the *Figure*. Fig. 42.

4. *Long Square.* This may be Fortified with half Baſtions as before, and a Tong, or as in the *Figure*.

5. *Star Redoubt of four Points:* This may have its Side from 40 to 60 Feet, and after you have deſcribed the Square, divide each Side into two equal parts at *m*, take one fourth of *p m*, or half the Side, and raiſing a Perpendicular at *m*, ſet off *m a* equal to the one fourth of *p m*, and finiſh the *Figure*. Fig. 43.

6. *Star Redoubts of five or ſix Points.* Firſt, for a Star Redoubt of five Points, make a Pentagon, *p p p &c.* and divide each Side in halves in *m*, and raiſe the Perpendiculars *m a*, take one third of *m p* and ſet it from *m* to *a*, and draw the Fort: And for a Sexangular Star draw an Hexagon, and divide a Side into four parts, and take one for *m a*, as before: This *Figure* may have a Side of 300 or 400 Feet. Fig. 44.

7. *Plain Redoubts*, are either ſmall or great; the ſmall are fit for Court of Guards in the Trenches, and may be a Square of 20 Foot to 30; the middle ſort of Redoubts, may have their Sides from 30 to 50 Feet; the great ones, from 60 to 80 Feet Square. Fig. 45, 46.

The Profiles (that is, the Thickneſs and Height of the Breſtworks) to be ſet on theſe ſeveral Works, and the Ditches, are alterable and uncertain; for ſometimes they are uſed in Approaches, and then the wideneſs of the Breſt-

Breſtwork at the bottom may be 7 or 8 Feet, Inward Height 6, and Outward 5 Feet, the Ditch may be 8 or 10 Feet, and ſometimes 12, and for the Slopes to be wrought according to the nature of the Earth; ſometimes they may be made 14 or 20 Feet wide at the bottom, and the Height of 7, 8, or 9 Feet, and to have two or three Aſcents to riſe to the Parapet, the Ditch may be 16 or 24 Feet wide, and 5 or 6 deep; and ſometimes they may come near the ſmalleſt ſort of Rampires, and have a Breſtwork Cannon-proof, with a Ditch of 50 or 60 Feet wide, and are thus made to ſet upon Paſſes or Rivers to endure.

CHAP. VI.

Of the Defence of a Fort.

§ 1. Of the Governour, Strength of Men, Victuals, Ammunition, and Inſtruments of War fit and neceſſary for the Defence of a Fort.

1. THe *Governour* of a Fort ought to be a good Soldier, a careful, diligent and knowing Man, to know all things belonging to a civil Life, to be juſt both towards the Inhabitants and Soldiers, being well aſſured and confident

confident of his Soldiers that they will ſtand by him before they be brought into the place, he ought to have an Eye and good Intelligence of the Manners, Life, and Condition of them both, and to have ſubtle and ſecret Spies amongſt them to know their Practices, their Pleaſures or Diſcontents: And for his Military Care, (that having been a part of his Imployment, ſome part of his Life) need not to be ſpoke off; to be ſhort, he ought never to ſlight danger, but muſt always ſuſpect and fear Surpriſes and Treaſons; he muſt mind his Government, and have his Place always in his thoughts, that it is his Honour to keep it, for the Intereſt of his Prince and Country, with the peril of his Life; and to that purpoſe to ſee that it be in good Eſtate, that the Ditches be clear, and all places without be kept pallizadoed and ſafe; laſtly, that he keep Regiſters and Books of all Things and Perſons within the Fort, to the end he may ſend in good time all unneceſſary Mouths away if he fear to be Beſieged.

2. For the Strength and Number of his Men, he muſt require them according to the Strength of his Enemy that ſhall Beſiege him, and according to the Capacity of the Place: For every Baſtion 300 Men may be reaſonable, that is 1500 Men for a Pentagon, 1800 for an Hexagon, ſo that 2000 Men may well be thought a good Garriſon: And this beſides the Townſmen and Artizans.

3. For Proviſion of Victuals, according to

the Number of his Soldiers the Demands of his Provisions must be; he must look that his Store-houses be neatly kept, and that he may have room enough to shift his Stores, in case the Enemies Cannon shall chance to beat any part down, that he keep an Eye over the Store-keepers, that no Provision be lost or made useless for want of care or turning.

4. The Ammunition and Instruments of War whereof the Governour must be provided are:

1. *Musquets with Bandaliers and Pikes* to spare, to Arm the Townsmen if need be, and to supply those that may be broken, or fall into the Enemies hands; and these he keeps in his Armory.

2. *Spare Ordnance* or *Great Guns*, half as many at least as he has Mounted, to supply those that shall be broken or disabled.

3. *Shot of all sorts*, as well for Great Guns as for Musquets, together with good store of Lead and Moulds to Cast Musquet-shot in.

4. *Powder* answerable, and several Magazines in the Fort to lodge it in, and in several Places, Vaults that are made under some part of the Rampire that have much Earth above them, and in such other Places where great Granadoes may not break into, are of all other the best in time of Service, however so to lodge the Powder in many Places, as the danger of Blowing up one may not destroy all. The Number of Barrels must be proportioned to the

the Rounds of great Guns, and number of ſmall Arms.

5. *Match* proportionable, and if the place be great, Match-makers to be imployed, to have Tow, Salt-petre, and other Materials ready.

6. *Shovels*, *Spades*, of each 1000, *Pick-axes* 500, Wheel-barrows, Hand-barrows, Rammers, all to be ready for removing Earth, or for Retrenchments, and to be provided with a *Drugg* for ſhifting great Guns.

7. *Spare Carriages* for the great Guns, Axle-trees and Trucks to ſpare, Plank of two Inches thick, Joiſts and Spars of each a quantity anſwerable to the bigneſs of the Garriſons, together with a Carpenter and his Men, with all Tools belonging to them.

8. *Cannon-Baskets*, which ought to be 3 or 4 Foot Diameter, and 5 or 6 Feet high; for the making of which there ought to be Riſe-wood and Stakes with Bills provided, (unleſs they can be made and ſent into the Fort,) theſe are called *Gabions*, and are to be filled with Earth, and to ſtand for great Guns to play betwixt, or for ſuch uſes. *Muſquet-Baskets* are ordinary, about a Foot or a Foot and half high, 8 or 10 Inches at the bottom, and a Foot at the top; theſe fill'd with Earth admit a Muſquet to be laid betwixt two at the Bottom, and are ſet on low Breſt-works, or upon Breſt-works beaten down. Two or three thouſand *Canvas-bags* ready made, ſome to hold a Foot or a Foot

and half of Earth; ſome leſſer that are but half ſo big, theſe are eaſily fill'd with Earth, and laid upon Parapets beat down, or upon the edges of Retrenchments, and for need Barrels and Hogs-heads fill'd with Earth may ſerve.

9. *Gins for lifting up Guns*, a Smith with a Forge with all Smiths Tools. Good ſtore of Iron and Steel, Nayls of all ſorts, Crows of Iron, Steel-Mills for grinding Corn.

10. *Piles* or *Pallizadoes* made of Spars 3 Inches thick or a little leſs in Diameter, 5 or 6 Foot high, wrought round, plated or ſhod with Iron at the Points, and having two or three great Iron Nayls driven through them towards the head 8 or 9 Inches long, being flat-headed on one ſide, the better to drive them in; theſe may be ſet in two or three rows, the loweſt Breſt-high, and every Row higher, and ſo one after another, ſo deep as they may not be pull'd up, may be planted on the top of a Breach, or on ſome Paſs on a ſudden.

11. *Turn-Pikes*, or Spars of 12 or 14 Foot long, and about 6 Inches Diameter in a Sexangular form; it is to be bored with holes one right under another about an Inch Diameter, the Axis of each Hole ſhall be 6 Inches one from another, but to go by turns from each ſide, the Pickets that are driven into the Hole are 6 or 5 Foot long pointed with Iron at both ends, and with Wedges or Nayls faſtened hard into the Holes; two of theſe faſtened together with an Iron-Chain and Staples ſome 6 Inches long,

long, will be of great use to stop the Enemies in the Breaches, or elsewhere. But those that you intend for to throw in Breaches must be made of Oak, and need not be so big, or the Pickets so long.

12. *Horse de Freeze* is made much like the former, but much stronger, and is used in stead of a Gate, is called a *Turn-Pike*.

13. *Crow-feet*, Chaus-Traps, or Calthrops, are four-pointed Irons, and may be made 2, 3, or 4 Inches long; to have thousands of these ready of each sort will be very convenient, the least will be useful to lay upon Bridges or Planks, the greater to strow on the Ground to hinder the Cavalry, they have always one Point upwards which way soever they be thrown.

14. *Beetles* of all sorts, both for two, three, or four hands, to drive Piles or Palizadoes with into the Ground, and for other uses.

15. *Two greater Morter-pieces*, and one lesser, with Granado-Shels, and all Materials belonging to them, these will be of great use to break the Galleries, and hinder the passage over the Mote, and may do much mischief to the Enemy in his neareſt Batteries, if carefully used.

16. *Hand-Granadoes* fitted with Fuzes 2000, and the Governour is to cause that many of his Souldiers may be expert and taught to throw and use them.

17. Lastly, the Governour is to have with

him a Fire-Maſter, to make the Fuzes and other Fire-works, as Fire-balls to ſhoot into their Redoubts and Batteries, and upon the Galleries and other places; and if the Enemy ſhall come to Mine and blow up ſome part of the Works, he muſt have his Men ready to make Cuttings off or Retrenchments, with Parapets either of Earth or Sacks, or the like filled with Earth; and above all he muſt have good ſtore of Money to pay Soldiers withall, elſe they will be mutinous and diſcontented.

CHAP. VI.

Of Beſieging Towns.

BEcauſe I am tied to a ſhort Diſcourſe, I ſhall onely give you the Terms, and refer you to great Volums writ of this Subject.

1. When a General and Army comes againſt a Town or Fort, they take care to ſtop all the Ways, Paſſages, and Intelligence that may be ſent either into or out of the Town, this is called *Blocking up the Town.*

2. The next thing is to chooſe a fit place to begin the *Line of Contra-vallation*, called *Breaking of Ground*, which is to be choſen beyond Muſquet-ſhot or Falcon from the Town, under which the Cavalry may ſecurely lodge: this Line is carried round about the Town if the Gar-

Garriſon be very ſtrong and full of Men, elſe not, but onely on one part.

3. If the Enemy have Armies neer, and that he will endeavour to raiſe the Siege before the Town can be taken, then there is another Line further into the Campaigne to be made, which is called a *Line of Circumvallation*; this Line is to be carried round about, incloſing Ground enough for all the Army to lodg in, and the Quarters of the General and other great Commanders are to be placed round about, ſo as one may relieve another conveniently. Upon this Line, within Muſquet-Shot one from another, are to be placed Redoubts, Long Squares with Tenails, Triangles with half Baſtions, Star-works, Field-Skonces, and other Forts formerly taught to be made, with Ramperts ſome 8 or 10 Foot thick, 6 Foot high, with Steps to mount upon the Parapet; the Outward Height 5 Foot, the Ditch 10 or 12 Foot wide, and 4, 5, or 6 Foot deep. Indeed theſe Works are to be made reſponſible to the Danger the Enemy may put the Army to.

4. The next thing to do is *Opening of the Trenches*, that is, beginning the Lines of *Approaches* towards the Town at about 1200 Foot from the Town, whereon firſt is to be built a Redoubt or Battery with Guns, and then the Line begins, which is to be carried on obliquely, ſo that no Shot can be made out of any Work of the Town that may ſcour that Line; with three or four Turnings you may approach

to the Counterſcarp-bank or *Glacis*. At the end of each Turning there muſt be a Redoubt built for Guards of the midddle or leaſt ſort of Redoubts before mentioned. The Width of theſe Trenches or Approaches may be 12 or 14 Feet at the top, the Depth may be 4 Feet, or ſuch that the Depth and the Bank made with the Earth thrown out, may be good and ſafe Cover for the Soldiers, it may be 6 or 8 or 10 Foot at the bottom, and two or three Steps muſt be made eaſily to get up to the Breſt-work. As you come nearer the Town, the deeper and wider you may make the Trenches; but if the Ground be Rocky, or Mariſhes with Bogs, then you muſt be provided of abundance of Hurdles, Cannon-Baskets and Bavins, ſpoken of in the laſt Chapter, and there deſcribed with their ſeveral Dimenſions.

5. As you are carrying on theſe Trenches, there muſt be built *Batteries for great Guns*, according to the number you intend to plant, and they may be *High Batteries*, which muſt be raiſed of Earth ſome 12 or 16 Foot high, or elſe made upon ſome Hill or riſing-ground when the Battery is made; the Breſt-work may be made with Cannon-Baskets, Sacks of Earth or Hurdles. The Guns muſt be 12 Foot aſunder for Shelter. This high Battery is to ſhoot into the Town, to beat down the Houſes, terrifie the Burgers, and to play continually day and night. *Middle Batteries* are raiſed 4 or 6 Feet above the Ground, and theſe are to beat down

down the Breſt-works, and Parapets of the Rampires, and other Works. *Low Batteries* are ſuch as are made even upon the Level-ſoil, and theſe ſerve to play upon the Rampire, and to beat down the Body of the Works.

6. In the carrying on the Lines of Approaches and Batteries, the Ingineers muſt be ſure to be provided of *Pallizadoes de Camp*, and Piles of 6 Foot, ſuch as was deſcribed in the laſt Chapter, *Turn-Pikes*, and *Horſes de Freez*, *Barricadoes*, that is a Fence made of Pallizadoes; *Chandileers*, that is Frames to lay Faggots or long Bruſh-wood in; *Mantelets*, that is Blinds made of Board, Muſquet-proof, either with one or two ſides running like a Wheel-barrow or upon Trucks, Man's height, under which one or two Muſqueteers may ſhelter; Blinds of Canvas two or 300 Feet, Thouſands of Crow-feet or Calthrops to hinder the March of Horſe, together with great ſtore of Plank and Timber ready.

7. When the Trenches are brought to the foot of the Counterſcarp-bank, then there ought to be made a *Line of Communication* betwixt the two or more Approaches that were carried on at one time. This *Line of Communication* is to be filled with Muſqueteers, who are continually day and night to ſhoot upon the Souldiers, who ſhall ſtand upon the Breſt-works before it, and to hinder the Enemy from ſhewing their Heads above the Works, whilſt the Cannon are beating down the Parapets, and levelling the Works.

8. The

8. The next is to enter in at the foot of the Counterſcarp-bank, and to carry on a deep Trench, which is called the *Sapp*; when it comes towards the Covert-way, it is ſo deep that it may be cloſed over, and it muſt be directed towards the Face, if that be the place that is intended to be Mined, which moſt commonly is, and not the Curtain, becauſe of the ſtrong Defence it receives from the two Bulworks.

9. When the Sapp and Mouth of it is brought to the Mote, then muſt good ſtore of Pioneers be imployed to run Earth in Wheelbarrows night and day to fill up the Mote. Firſt they begin at the Mouth of the Sap, and fill that place, ſo as there may be gotten a good Mount, to cover the Pioneers from the danger of the Enemy. The Mount is to be raiſed on that ſide which reſpects the Enemies Curtain and oppoſite Flank, and ſo to be wrought and roled on(keeping ſtill ſufficient Covert,Cannon proof, towards the Enemy) till you have made it flat and levell to the water. That you may bring on your *Gallery*, firſt, you bring two Frames of Timber ſome 8 or 10 Feet wide,and the Height 9 Feet; the Frames ought to be 8 Inches and 6, and that ſide reſpecting the Enemies Flank, let it be double Plank'd: when two pair of theſe Flanks are made, then muſt they be plank'd, with ſome longer ſome ſhorter Planks and Timber to joyn them together. Theſe Frames are to ſtand 6 Foot from one another,or 7, and to be ſet one after another, 'till the

the Gallery reach to the foot of the Baſtion. This Gallery thus made is to be covered at the top with a Foot thick of Earth, to hinder Fire-balls from burning it; and Chandeleers and Faggots may be planted on the ſides to ſave the Pioneers.

10. After you come to the Face, the next is to make a *Mine*, which is to be done with Miners, who are to have Pick-Axes, Hacks, and other Inſtruments fit for that purpoſe. The Mine is made commonly about 4 Foot wide and high, and by ſeveral Turns wrought on, to prevent the Blaſt of Powder coming forwards; when you are come to a convenient place, which ought to be further than the Outward Talu, then make a place for the Powder 10 or 12 Feet wide, and 5 Feet high: place the Powder herein, and cloſe up the mouth of the Mine, which muſt be carefully done, putting croſs Timbers in every Return, leaving a Trunk or hollow Pipe all the way fill'd with Powder. This Work muſt be fired as ſoon as conveniently may, leſt the Powder take harm by too much moiſture, after which follows the Aſſault, if the Breach be made conſiderable.

But that the former Directions may be better underſtood, take a ſhort Diſcourſe writ by Monſieur *De la Mont* in *French*, Of Fortification Offenſive and Defenſive, printed at *Paris*, 1671.

CHAP.

CHAP. VII.

The way and manner how to Besiege, Attaque, and Defend a Fortified Town or Place.

ALL agree that to gain Time is the greatest Advantage: therefore as well those that Attaque as those who are Besieged, ought always to be in a continual suspicion the one of the other; else sometime or other the one party will certainly be surprized, and both ought to encourage their men, the one to get Ground, the other to maintain it. But before I enter into the Discourse, I will reflect upon two different Garrisons; for in that which is strong, one ought quite in another manner to act, then in that which is weak.

Therefore I will represent in this Scheme a Regular Heptagon with all its Dimensions, and about which place I will shew four different Attaques. Two of which are carried on forward, the other two are kept back by two Sallies, or Trenches made by the Garrison of the place, to meet and drive back the Besiegers.

Therefore to draw out the two first Attaques, I will propose an indifferent Garrison, doing all things possible for its Defence, by preserving

ſerving its Men, and diſputing for Ground, which the Beſiegers cannot win but Inch by Inch. Firſt, we will examine the Conſiderations of the Attaque of a place, then we will ſpeak of its Defence.

As ſoon as the place is block'd up, and conſequently the reſt of the Army, Baggage, Proviſions, Ammunition of War, and the Artillery are arrived, and the General hath form'd out his Camp, they begin to make the Lines of Circumvallation, and of Contravallation if there ſhall be neceſſity, and when they have thoughts to open the Trenches, the Collonel or Commander of the Infantry (whoſe buſineſs it is to open them) ought early in the morning to viſit the General, or more particularly the Lieutenant General, if he be appointed for this Action. He ought alſo to have well reviewed the place himſelf, before he hath been with thoſe who ſhall pretend to know it. But ſuppoſe that be done, and the place for the opening of the Trenches appointed out, you muſt begin with a great place of Arms, and two great Eſpaulments well Flanqued, which can or may cover the Cavalry from the Enemies Cannon, and make on one ſide of it a Battery of ſeveral pieces of Ordnance, well Flanqued and defended by the ſaid place of Arms, and by the Line of Communication of the Trenches, to the end that this Battery may continually play upon thoſe of the place, to indeavour to diſmount their Cannon, or at the leaſt to bring the Enemies Shot thither, by which

which means they may be diverted from firing into the Trenches, in which time the Parapets of the Trenches may be enlarged and fortified, and the ſaid Line of Communication or Approaches may be carried on directly towards the Flanqued Angle of one of the Baſtions, if there be onely Demi-Lines or Ravelins, which defend or cover the Curtains, and in the length of every 750 Feet or 120 Toiſes or Fathoms, to make a Traverſe to Flanque the Trenches, and good places of Arms in the winding or returning of the Trenches, and moreover Redoubts if the Garriſon within be ſtrong: and that the other Attaque be alſo drawn right to the other Flanqued Angle of the next Baſtion, to the end that three Demi-Lines and two Baſtions be attaqued at the ſame time, if it is found neceſſary; which will divert the Enemies Force and Firings, who will be jealous of every place, and equally imploy their ſtrength for each. There muſt be alſo a good Line of Communication drawn betwixt the two Trenches, to take and fortifie the Ground betwixt the two Attaques, by which means the Enemies coming to ſally out, will always find themſelves betwixt two Firings. Care alſo muſt be taken that the Batteries be out of danger, and that the Cannon be ſo placed, that when they play, the Shot may paſſe over the Trenches; otherwiſe you will many wayes incommode your ſelf, and the Enemies Cannon will fire into the Trenches in the ſame time as they play againſt your Batteries,

You must advance the Batteries in the same time as you advance your Attaques, and the best place in which you can place them is betwixt the two Attaques; for when you are become Masters of the Flanqued Angle, you may with all the facility imaginable divide your Battery in two, and dispose it in such manner upon the said Flanqued Angles, that you may be Masters of the Firings of the two Flanks of the two opposite Bastions, and of the Ditch. Wherefore it follows, that you lengthen out Saps all along the Brest-work of the Counterscarp, and there make great Lodgments, in the middle of which you cut your Descent into the Ditch, which you may fill up, or make good sure Galleries, and set your Miners at work without hindrance, as is represented in this Figure.

If there be great Out-works, as Horn-Works much advanced, you must attaque them in the same manner, and they being taken will much endammage the place because of their Elevation, upon which you may lodge Cannon, and oftentimes discover the Counter-scarp, the Distance of the Bastions, and some parts of the Rampert; because they never make these sorts of Fortifications, but to take in some commanding Ground, or to cover some Infirmity of the place. But above all things you must order your Trenches with so much care, and to Flanque them and render them so good and so secure, that thinking to advance them by a Mo-

tive

tive of Oſtentation or Vanity, one may be obliged to abandon them, if they be ſlight, and lye too much open. Therefore the General, whoſe Intereſt it is to preſerve his Men, ought not to divide his Care amongſt the Intereſts of the Lieutenant General, and Marſhals of the Camp, or the reſpective Regiments, but ought himſelf to viſit them every day in the Evening, and have a Care that they may be made good.

The Colonels and Commanders ought alſo, entring into the Trenches, to ſupply and punctually to furniſh them with Faggots, Sacks of Earth, Gabions, Pick-axes, Spades, Shovels, Mattocks, that the work be not diſcontinued, or ſuffer any delay, and at the head of the Camp to make ready all the ſmall Parties to ſupport the Pioneers, and defend the head of the Trenches, and to ſend 8 or 10 truſty Soldiers, two by two, ſeparated far off the one from the other before the Works, to liſten if they hear any perſons coming from the Town, to diſcover the part which is to be attaqued, and there to ſtay (as I have ſaid) a good diſtance before the Works, each having a Partizan or half Pike in his hand, and one or two Piſtols on each ſide, to ſeize on thoſe they meet or ſhall fall into their Ambuſcado, which would be a great advantage; for by thoſe you may know the Strength and Weakneſs of the Place, and Strength of the Garriſon, and alſo to ſend out a Party of 200 Men to the right and left of the Trenches, ſomething farther than they are traced

ted out, who ought to keep themſelves in Battaillion or Batallia laid under their Arms, with Sentinels ſomething advanced to advertiſe them of the Enemies Sallies, to keep hid their Matches, and if they had Snap-Hances upon this Occaſion they would be far more commodious, and to have in the firſt rank a quantity of Partizans to oppoſe Sallies, and to give courage to the Pioneers, and time for the Horſe to mount, and thoſe in the Rear of the Trenches to advance and meet the Enemy.

The reſt are things ſo ordinary, that the Inferior Officers are not ignorant of. All which are repreſented in this Figure by the two Attaques A. B.

To Defend a Town or Fort.

AS ſoon as an Army or Party makes their Approaches againſt your Place, and forms their *Blocus*, or *blocks you up*, you are to ſhoot off ſeveral Cannon, to inform the Countrey round, and give the Signal of Retreat, that all the Parties without may come in with the Cattle, and all that is found about the ſaid place: moreover you are to ſend to the Batteries the Gunners, with order to make ſeveral Shot to keep off the light Horſemen and Spies that they approach not ſo neer as to view your Works, as alſo to favour the Foot and Horſe, who ought every day to make a Sally, to ſhew

that your Garriſon is ſtrong and in good heart, but with order that the Infantry go not out of Muſquet ſhot. For the Cavalry, they ought every day from the opening of the Trenches to ſally in ſmall Squadrons, or after the *Cravats* faſhion, to draw the Army near, that it may lye open to the Cannoneers, who may make ſome good Shot, and cut off ſome Principal Officers.

Therefore before one enter into the particulars of Defence, one ought to diſtinguiſh them according to two different Maximes, which muſt be ſpoken of apart; for if your Garriſon be ſtrong, you ought quite in another manner to govern it, as if it be but indifferent or weak: for there are ſcarcely any other Meaſures to take then to mannage your Garriſon to the beſt advantage, and not obſtinately to defend your Out-works, but rather to look to the Defence of your Ditch, and the Body of your Place by your Cannon, with which your Flanks are to be extremely well furniſh'd. And as ſoon as you perceive the Attaques of your Enemy, you are to Counter-mine the Flanqued Angles of your Demi-lines or Ravelins, which you ſhall blow up at ſuch time as you are forced to quit them. You muſt diſarm all the Inhabitants of the Town, forbidding them upon pain of Death not to ſtir out of their Houſes without order, and a Patroull is to march day and night to execute with preſent Death the Orders given, and the ſmalleſt Examples in this Nature will do exceeding well. Laſtly, having retrenched your Baſtions,

after

after a considerable Breach you may make your Capitulations. This is all a weak Garrison can do.

If your Garrison be indifferent strong, and of the Kingdom whose Inhabitants are faithful and affectionate, you may choose out a select Company of the most Couragious to mix in your own Companies ordered in your Out-works and Bastions, but never in your Sallies. You must forbid the Inhabitants upon pain of Death not to assemble, without order, more than 10 or 20, neither to go armed to Church, and that they keep within after the Drum sounds *Tat-to*, and not to stir out either armed or not armed upon pain of Death untill the morning at 7 a Clock, without order be given, as in danger of Fire, or some other urgent necessity; and in case they do otherwise, to execute the Orders without remission; to forbid all Magistrates and other Inhabitants, of what condition soever they be, to propose or capitulate with the Enemy upon pain of being Hanged immediately up without any form of Justice, and to execute them without mercy in case of breach of the Commands. Being resolved to defend your Out-works with Obstinacy, to husband your Provisions, to Countermine round about those Out-works as the Enemy shall attaque, and to give fire to the purpose, to retrench all your Half-Moons, and make Retrenchments and Barricadoes all along the Covert-way, to lose all things Inch by

Inch, and to quit nothing but by main force; and to gain more time, ſome of your moſt faithful and ſtouteſt Soldiers are to ſally with Fire-Locks, two by two, and three by three, who are to fire upon the Pioneers, with great ſhouting after the *Mooriſh* faſhion, afterwards to retreat into the Counter-ſcarp without farther reſcue; to make often theſe little Sallies, and never let the Pioneers be in reſt, or the Trenches quiet, to keep all the Soldiers in readineſs to give fire as ſoon as your party is return'd, by which generally many Officers are kill'd that do advance.

After a Stormy or Rainy night, to make a great and brisk Sally about Sun-riſing or break of Day, as Opportunity ſhall admit, with a quantity of Nayls to cloy the Guns, Pick-axes, Spades, Shovels to throw down their Lodgments, with Flails, Spears, *Manches de Revers*, and other terrible Inſtruments; one dozen of Granadiers, a quantity of Muſquetoons to make a conſiderable Aſſault; to throw down the Works in ſuch manner, that the Enemy coming to regain Ground may lye open to the Shot from the Out-works, which ought then well furniſhed and in readineſs to make a continual firing to favour the Retreat of the Sally. And by this means the Enemy ſhall not gain a Foot of Ground, but at a very dear Rate; and being reduc'd to the Ditch, you are there to make little Mines ready to blow up, Coffers or Foucades at the Foot of all the Shoulder-Angles

of

of the Baſtions, which Flanques all along the Faces, and ſees all along the Curtain. There is nothing makes greater Slaughter, or with greater eaſe hinders Undermining, than to have your Flanks well furniſh'd with Cannon, which may beat upon the Flanqued Angles, and ſcour the Ditches. It is almoſt impoſſible for the Enemy to enter there, to make any Lodgment, or ſet any Miners to work upon the Body of the place; ſo that being not able to make a Breach but by their Cannon, it is repaired, and the Baſtion cut off, and retrench'd with the Mines prepared under the Breach, and the Batteries made firm before they can ſtorm, and for three days they cannot make any Lodgment, notwithſtanding they have won all the Flanqued Angles, and made a Breach of 12 Fathom to the very foot of the Baſtion, yet they cannot maintain it but with great loſs, nor can they avoid the Granadoes and Fireworks that will continually be caſt upon them, and will be reduced to approach there, by Sap, and one may meet them counter-ſapping with the greateſt facility imaginable, becauſe one has had leiſure enough to prepare them by Lodgments made expreſs for that purpoſe. So that theſe Seiges laſt for an Age, and make great Armies periſh, neither can they come to their intended purpoſe, as is repreſented in this Figure, by the two Attaques A. B.

As for ſuch Places as have a ſtrong Garriſon, it ought always to have ſmall Parties out, to be

poſitively advertiſed what part the Enemy will attaque; as ſoon as that is diſcovered, they ought always to annoy them by continual ſmall Sallies, two by two, who creep into the Field unperceivable, and fire upon the Pioneers. The Out-works are to be well furniſhed with men to keep continually firing, and to render them more able they are to be reliev'd twice a day, and twice a night, to make a great Sally after Rain and the labour of the Night, at Break of Day as aboveſaid. One may alſo bring in the Enemies Cannon at certain Conjunctures as may happen, eſpecially at ſuch time as you underſtand what part the Enemy intends to attaque, you meet them in the ſame manner as they approach you. But you are to obſerve to work forward on, from the two inward Angles of the Covert-way, as it is marked in this Figure, that you may be defended by the two Faces of the Baſtions, and by the Covert-way, and to cloſe always by two inward Angles, as you ſee repreſented by the two Points in the Figure R in this Scheme, and marked by C D. And as ſoon as you have workt out of Falconet Shot, you are to cloſe them by the Figure of two half Baſtions as is repreſented.

This being done, the Enemy is obliged to attaque you there, ſo that the ſame Retrenchments that you have made to ſtrengthen your ſelves, the ſame time you advance your Works, and form your Figure to ſerve you to retire foot by foot, and your Enemies cannot gain them

but

but foot by foot, alſo puſh of Pike, and with incredible loſs. And for as much as you are under Cover, and they cannot execute any thing but by lying open, neither can they inſult over you, becauſe you have Retrenchment upon Retrenchment, and Out-works flanqued every where; and laſtly, covered by your Baſtions and Counterſcarp, neither can they ſhun you or attaque you elſewhere, for they would put them betwixt two Firings. So that the greateſt Armies in the World could not advance but by much time and meſtimable loſs, and that is properly to undertake the works of *Ixion* as to attaque a great Garriſon furniſhed with Officers of ſuch Abilities.

Within the Town you are to hinder the aſſembling of the Inhabitants by a *Corps de Guard* in the middle of the place, and by *Patrouills* marching day and night through the Town. And for the other Cares and Politick Circumſpections of the Governours I will not ſpeak of them, being a ſubject too long, only all this being writ for an ordinary Capacity.

Here followeth the Table of Angles, taken out of Count *Pagan*; the firſt Column under the word *Baſe* or *B* are every two Inches to one Foot; then from one Foot every two Inches to two Feet, *&c.* The ſecond Column are the Degrees and Minuts anſwering to the ſaid Baſe in a Triangle, which has the two containing Sides 30 Feet a piece. The Baſe may alter from nothing to 60, when the two containing Sides will then be a ſtreight Line.

A Table of Angles to a Base of 30 Feet.

Base.	Angles.	Base.	Angles.	Base.	Angles.
(00)	00°:00′	(05)	09°:34′	(10)	19°:11′
2	00:19	2	09:53	2	19:30
4	00:38	4	10:12	4	19:50
6	00:57	6	10:31	6	20:19
8	01:08	8	10:50	8	20:29
10	01:36	10	11:09	10	20:48
(01)	01:55	(06)	11:29	(11)	21:08
2	02:14	2	11:48	2	21:27
4	02:33	4	12:08	4	21:46
6	02:52	6	12:27	6	22:06
8	03:11	8	12:46	8	22:25
10	03:30	10	13:05	10	22:45
(02)	03:40	(07)	13:24	(12)	23:05
2	04:08	2	13:43	2	23:24
4	04:28	4	14:02	4	23:44
6	04:47	6	14:22	6	24:03
8	05:06	8	14:41	8	24:23
10	05:25	10	15:00	10	24:42
(03)	05:44	(08)	15:20	(13)	25:01
2	06:03	2	15:39	2	25:21
4	06:22	4	15:58	4	25:41
6	06:41	6	16:18	6	26:01
8	07:00	8	16:37	8	26:20
10	07:20	10	16:56	10	26:40
(04)	07:39	(09)	17:15	(14)	26:59
2	07:58	2	17:34	2	27:18
4	08:17	4	17:54	4	27:38
6	08:36	6	18:13	6	27:58
8	08:55	8	18:32	8	28:18
10	09:14	10	18:52	10	28:38

A Table of Angles to a Base of 30 Feet.

Base.	Angles.	Base.	Angles.	Base.	Angles.
(15)	28°:57′	(20)	38°:56′	(25)	49°:15′
2	29: 17	2	39: 17	2	49: 36
4	29: 37	4	39: 38	4	49: 57
6	29: 56	6	39: 58	6	50: 18
8	30: 16	8	40: 18	8	50: 39
10	30: 36	10	40: 38	10	51: 00
(16)	30: 56	(21)	40: 59	(26)	51: 21
2	31: 16	2	41: 19	2	51: 42
4	31: 36	4	41: 40	4	52: 03
6	31: 56	6	42: 00	6	52: 24
8	32: 16	8	42: 20	8	52: 46
10	32: 35	10	42: 40	10	53: 08
(17)	32: 55	(22)	43: 01	(27)	53: 29
2	33: 15	2	43: 22	2	53: 51
4	33: 35	4	43: 41	4	54: 12
6	33: 55	6	44: 03	6	54: 34
8	34: 15	8	44: 24	8	54: 55
10	34: 35	10	44: 44	10	55: 16
(18)	34: 55	(23)	45: 05	(28)	55: 38
2	35: 15	2	45: 26	2	56: 00
4	35: 35	4	45: 46	4	56: 22
6	35: 55	6	46: 07	6	56: 43
8	36: 15	8	46: 28	8	57: 05
10	36: 35	10	46: 48	10	57: 26
(19)	36: 55	(24)	47: 09	(29)	57: 48
2	37: 15	2	47: 30	2	58: 10
4	37: 36	4	47: 51	4	58: 32
6	37: 56	6	48: 12	6	58: 54
8	38: 16	8	48: 33	8	59: 16
10	38: 36	10	48: 54	10	59: 38

A Table of Angles to a Base of 30 Feet.

Base.	Angles.	Base.	Angles.	Base.	Angles.
(30)	60°:00′	(35)	71°:22′	(40)	83°:37′
2	60:22	2	71:47	2	84:03
4	60:44	4	72:10	4	84:29
6	61:06	6	72:33	6	84:54
8	61:28	8	72:56	8	85:20
10	61:50	10	73:20	10	85:46
(31)	62:13	(36)	73:44	(41)	86:13
2	62:35	2	74:08	2	86:39
4	62:58	4	74:32	4	87:05
6	63:20	6	74:56	6	87:32
8	63:43	8	75:20	8	87:58
10	64:05	10	75:44	10	88:25
(32)	64:28	(37)	76:09	(42)	88:51
2	64:50	2	76:33	2	89:18
4	65:13	4	76:57	4	89:45
6	65:36	6	77:22	6	90:12
8	65:58	8	77:46	8	90:39
10	66:21	10	78:09	10	91:06
(33)	66:44	(38)	78:35	(43)	91:33
2	67:07	2	79:00	2	92:01
4	67:30	4	79:25	4	92:29
6	67:53	6	79:50	6	92:56
8	68:16	8	80:15	8	93:24
10	68:39	10	80:40	10	93:52
(34)	69:02	(39)	81:05	(44)	94:20
2	69:25	2	81:30	2	94:48
4	69:48	4	81:35	4	95:16
6	70:12	6	82:20	6	95:45
8	70:35	8	82:46	8	96:13
10	70:59	10	83:12	10	96:42

A Table of Angles to a Base of 30 Feet.

Base.	Angles	Base.	Angles.	Base.	Angles.
(45)	97°:11′	(50)	112°:53′	(55)	132°:53′
2	97:40	2	113:28	2	133:41
4	98:09	4	114:03	4	134:30
6	98:38	6	114:38	6	135:20
8	99:08	8	115:14	8	136:11
10	99:37	10	115:49	10	137:03
(46)	100:06	(51)	116:26	(56)	137:57
2	100:36	2	117:02	2	138:49
4	101:06	4	117:39	4	139:44
6	101:36	6	118:16	6	140:40
8	102:07	8	118:53	8	141:38
10	102:37	10	119:31	10	142:36
(47)	103:08	(52)	120:09	(57)	143:36
2	103:39	2	120:47	2	144:39
4	104:10	4	121:26	4	145:43
6	104:41	6	122:06	6	146:48
8	105:12	8	122:45	8	147:57
10	105:44	10	123:25	10	149:08
(48)	106:16	(53)	124:06	(58)	150:20
2	106:48	2	124:47	2	151:36
4	107:20	4	125:28	4	152:55
6	107:52	6	126:10	6	154:19
8	108:25	8	126:52	8	155:48
10	108:57	10	127:35	10	157:22
(49)	109:30	(54)	128:19	(59)	159:03
2	110:04	2	129:03	2	160:53
4	110:37	4	129:48	4	162:54
6	111:11	6	130:33	6	165:12
8	111:44	8	131:19	8	167:48
10	112:18	10	132:06	10	171:28

There be many other things belonging to this Art, which the Limitations I am bound to will not give Liberty to set down; I give you nevertheless a Catalogue of such Books as I have by me, to the end (if the Reader please) by such he may be inform'd of such Works, Instruments, and Engines of War, as have been made by the most Expert and ablest Ingineers, since great Guns were in Use.

Books in Folio.

1. *Roberti Vulturii de re militari.* Lat. *Paris.* 1532.
2. *Discourse d'Architecture de Guerre Anvers.* 1579.
3. *Fortification per Castriott.* It. *Venice.* 1584.
4. *Lucar's* Solace and Colloquies. Eng. *London.* 1588.
5. *Fortification. de Errard de Barladuc.* Fr. 1604.
6. *Le Artiglevia di Pietro Sardi.* It. *Venice.* 1621.
7. *Rerum ad Sylvam Ducis Historia.* Lat. *Lug. Bat.* 1631.
8. *Hexam's* Art Military in 3 parts. *Lond.* 1637.
9. *Ward's* Animadversions of War. *Lond.* 1630.
10. *Fortification delle Citta.* It. *per Maggi.* 1614.

11. *Les*

11. *Les Fortifications de Count Pagan.* Fr. 1645.
12. *Peribologia Wilhelmi Dilichii.* Lat. 1641.
13. *Architectura Militaris Matth. Dogen.* Lat. *Am.* 1647.
14. *Fortifications Anth. de Villa.* Fr. *Lyons.* 1641.
15. *Regles General. de Fort. per Hondium* Fr. *Hague.* 1625.
16. *Fortification Lorini.* It. 1609.
17. *Architectura Militaris per Fritach.* Fr. *Leyden.* 1635.
18. *Architectura Militaris Maralois.* Lat. *Amst.* 1633.
19. The same in English by *Hexam.* 1638.
20. *Offesa & Defesa Piazza per Piet. Paulo. Venice* 1654.
21. *Josephi Furtenbach opera.* 1645.
22. *Corona Imperiale Sardi.* It. 1618.
23. *Corona Dogale Pietri Sardi.* It. 1628.
24. *Corona è Palma Mil. per Capo Bianco.* It. 1648.
25. *Fortification. Tensini Venice.* 1630.
26. *Flavii Vegetii de re Militari.* 1616.
27. *Obsidio Corbiensis.* Lat. *Paris.* 1637.
28. *Regale Militare per Melro.* It. 1611.
29. *Obsidio Bredana.* Lat. *Antwerp* 1626.
30. *Justii Lypsii Poliorceticon.* Lat. *Ant.* 1599.
31. *Architectura Militar.* It. *Venice.* 1638.
32. *Obsidio Grolliæ per Grotium.* Lat. *Amst.* 1629.
33. *Artillerie par Diego Uffano Zutphen.* 1621.
34. *Ars magna Artillerii per Deimoniwitr.* Lat. *Amst.* 1650.

35. *Tac-*

36. *Taequet Architectura Mil.* Lat. *Am.* 1669.
36. Strengthening of Strong Holds by *Ruce. London.* 1668.
37. *Hydrography. Furnier.* Fr. *Paris.* 1667.
38. Military and Maritine Diſcipline. *Lond.* 1672.
39. *Diſcourſi delle Fort di Carolo Theti.* It. 1589.
40. *Il. Principe defeſo Flamelli.* It. 1604.
41. *Queſiti militar. Flamelli.* It. 1606.
42. *Theatr. milit. Cap. Flaminio.* It. 1617.
43. *Des Fortifications de Jacques Perret.* Fr. 1620.
44. *Carichi mil. del Brancaccio.* It. 1620.
45. *Novum & magnum Theatrum urbium Belgicæ, Regiæ & Fœderatæ, Jo. Blaeu.* 2 *vol.* Lat. 1652.

In Quarto.

1. *Il perfeto Bombardiero* It. *per Gentilini.* 1626.
2. *Proteo militare de Bart. Romano.* It. *Nap.* 1595.
3. *Norwood's* Fortification. *London.* 1639.
4. Military Diſcipline by *Bariffe. Lond.* 1643.
5. *Metius de Munitionibus,* Lat. *Lugd. Bat.* 1626.
6. *Smith's* Art of Gunnery.
7. *Bourn's* Art of Shooting in great Ordnance.
8. Gunner's Dialogue, by *Robert Norton.*

9.

9. *Le Bombardiero Veneto* It *Venice.* 1631.
10. The Complete Cannoneer. Eng. 1663.
11. *Amuſſis Ferdinandea per Gaſp. Schottus.* 1662.
12. *Philippus Flemingus de Obſid. Oſtenda.* 1662.
13. Fortifications by *Gerbier.* Eng. 1648.
14. *Tractatus Inſtru Fr. Cnopii.* Lat. 1633.
15. *Trattatu dell: Artiglieria di Tho Moretti.* 1665.

In Octavo *and* 12o.

1. *Les Diſcours mil par le Sr. du Praiſſac.* 1615.
2. Art of War by the Lord *Praſſaic. Cambr.* 1639.
3. *Practique de le Guerre per Malthis.* Fr. 1668.
4. *Element. Arch. mil. per Nich. Goldman.*
5. *Prattique & Maximes de Guerre per Valier. & le Mot.* 1671.
6. *Breeve Trattato del Modern. Fort.* It. 1665.
7. Art of Gunnery by *N. Nye.* Eng. 1647.
8. Enchiridion of Fortification. *Lond.* 1645.
9. *Les Trauaux de Mars en trois parties.* Fr. 1671.

Soli Deo Gloria.

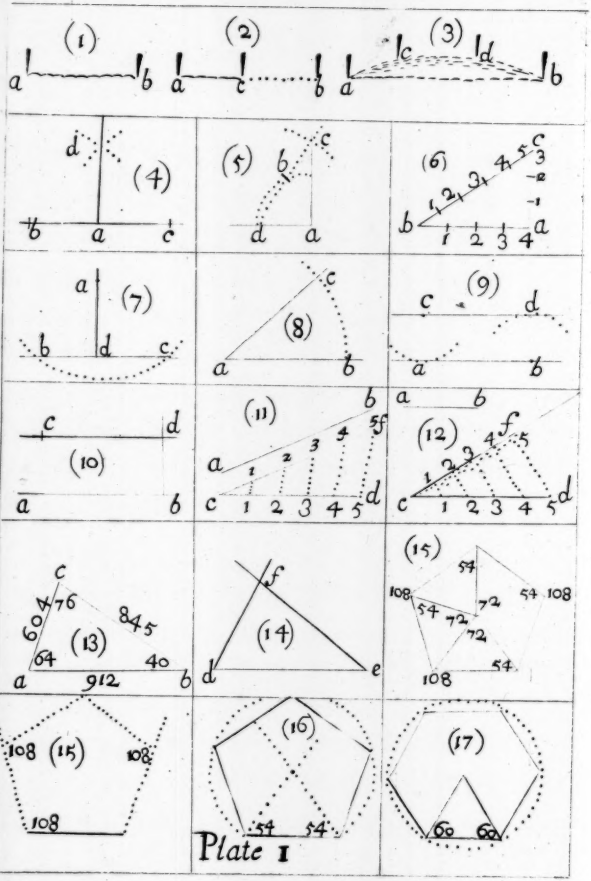
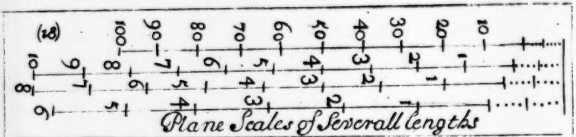


Plate I

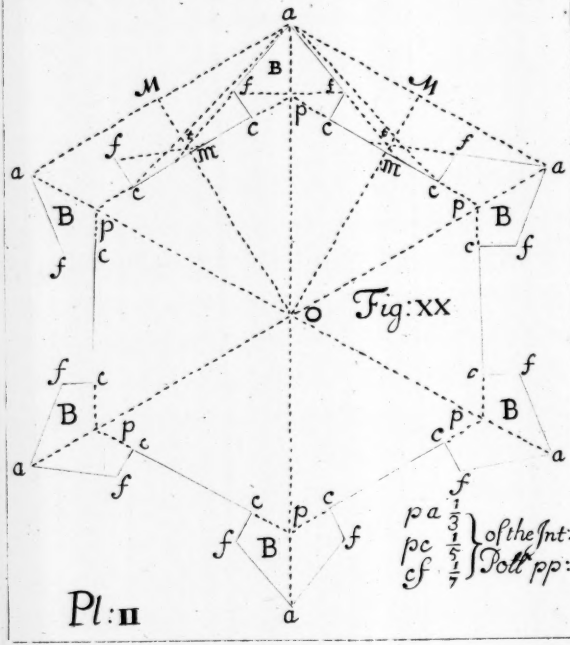
(18)

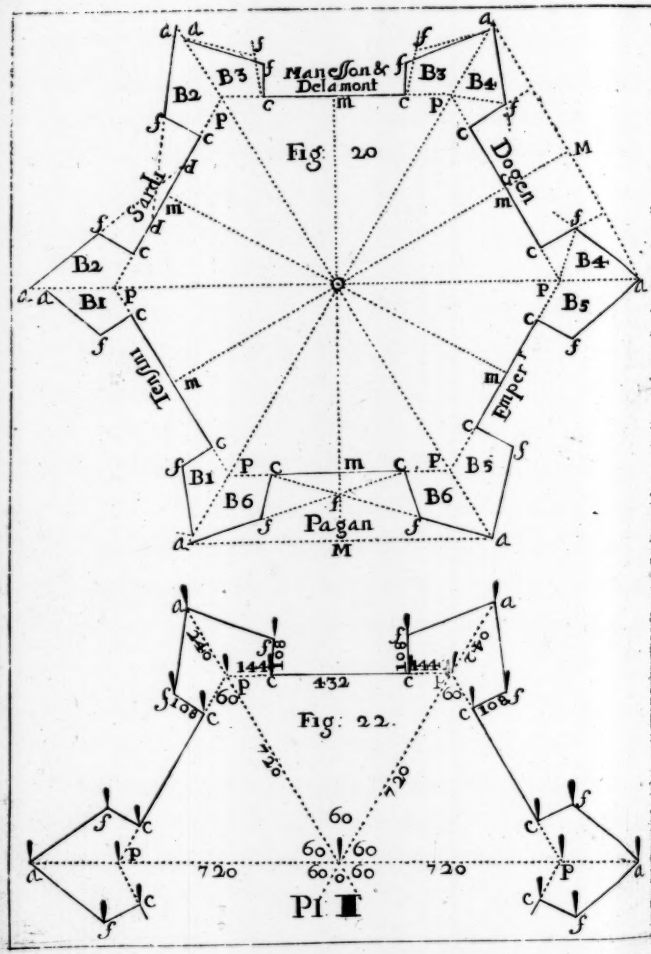


Plane Scales of Severall lengths

Diagonall Scale

(19)




Manesson & Delamont
Fig. 20
Sarda
Dogen
Tensini
Emper
Pagan
B1
B2
B3
B4
B5
B6
Fig. 22.
144
108
432
720
60
Pl. II

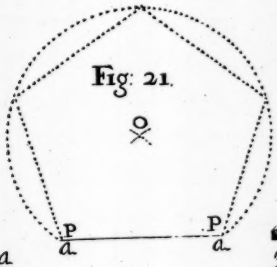


Fig: 21.
P
P
a
a

Fig: 27
5
7
15

Fig: 28

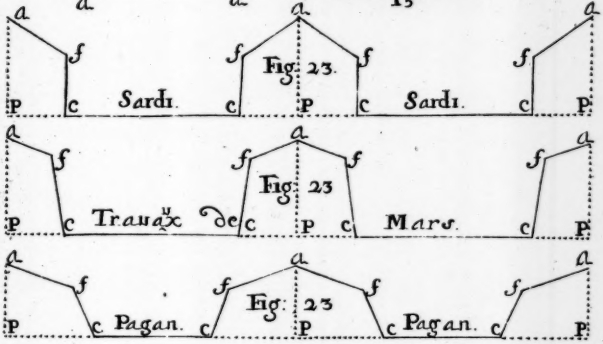


Fig: 23.
Sardi.
Sardi.
Fig: 23
Travaux de
Mars.
Fig: 23
Pagan.
Pagan.

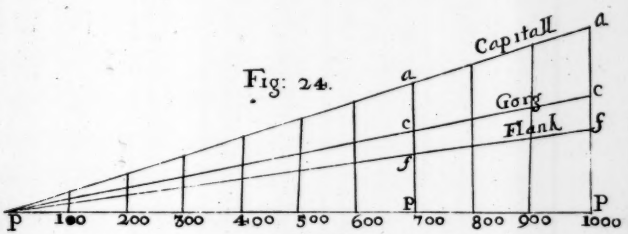


Fig: 24.
Capitall
Gorg
Flank
100
200
300
400
500
600
700
800
900
1000

Pl. II

Pl V

An equall Scale for the Profile of Feet

0 10 15 20 50

Figs

A Scale for the Rampire

50 100 200

Fig 26

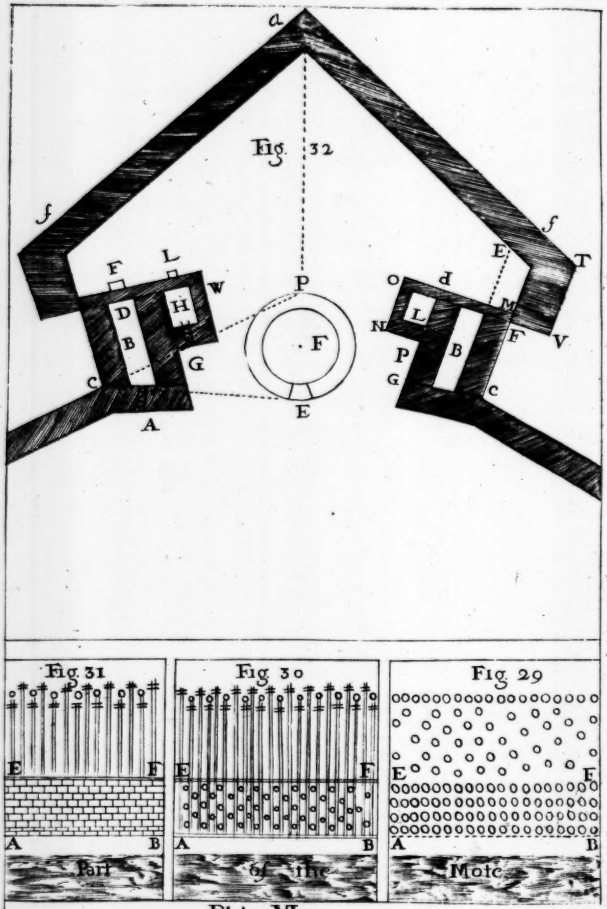


Fig. 32
a
f
f
F
L
W
D
H
B
G
C
A
P
F
E
E
T
O
d
M
N
L
F
V
P
B
G
C
Fig. 31
E
F
A
B
Part
Fig. 30
E
F
A
B
of the
Fig. 29
E
F
A
B
Mote

Plate VI

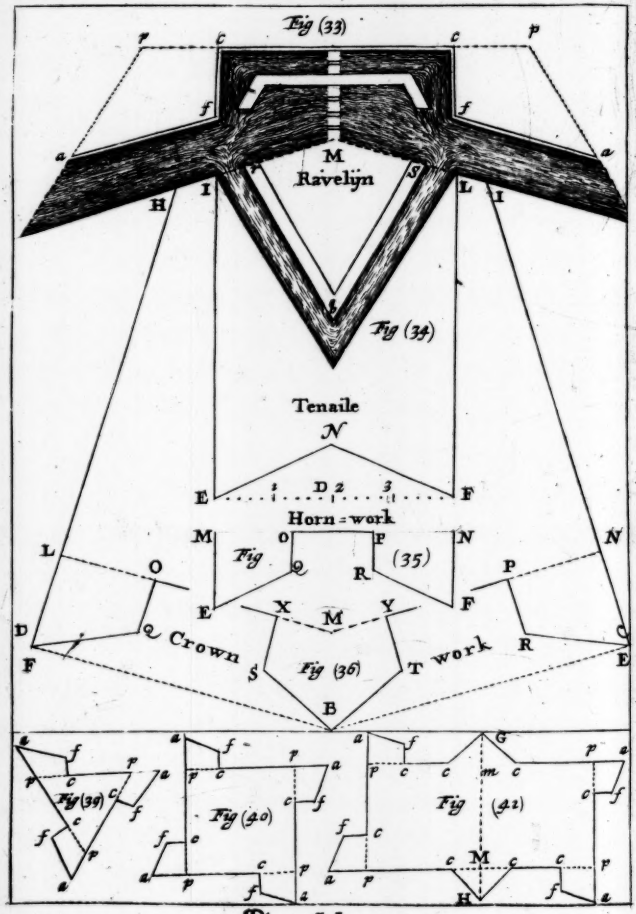


Fig (33)
M
Ravelin
Fig (34)
Tenaile
N
Horn-work
Fig (35)
Crown work
Fig (36)
Fig (39)
Fig (40)
Fig (41)

Plate VII

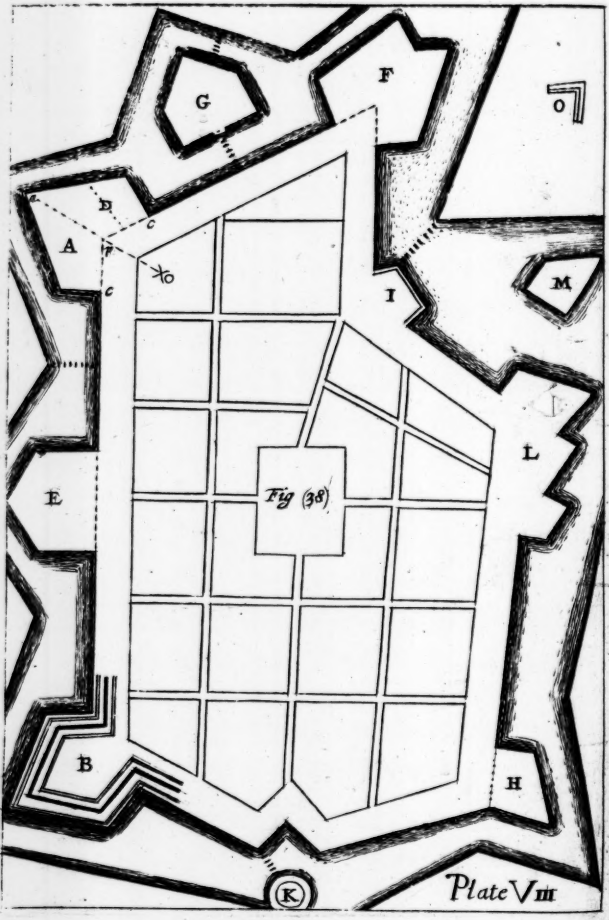
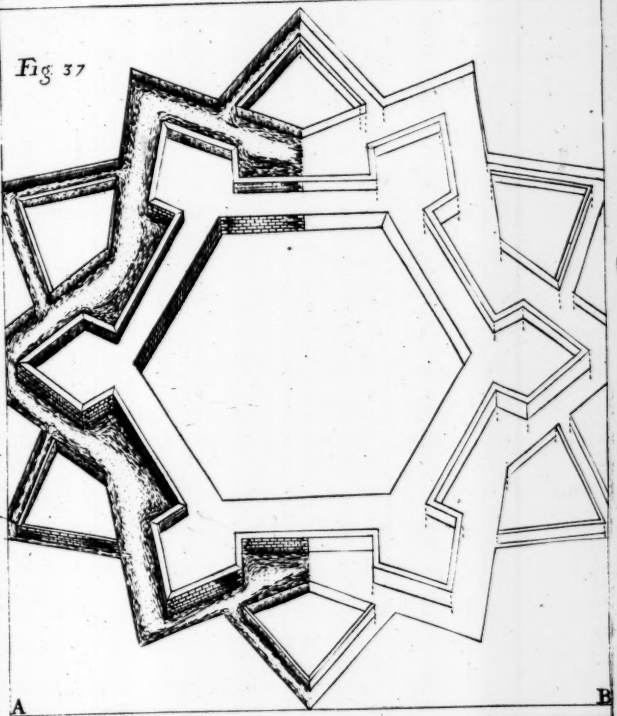
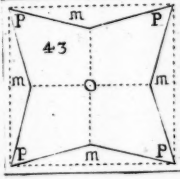
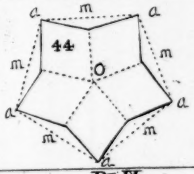


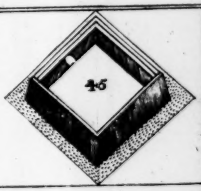
Plate VIII

Fig 37

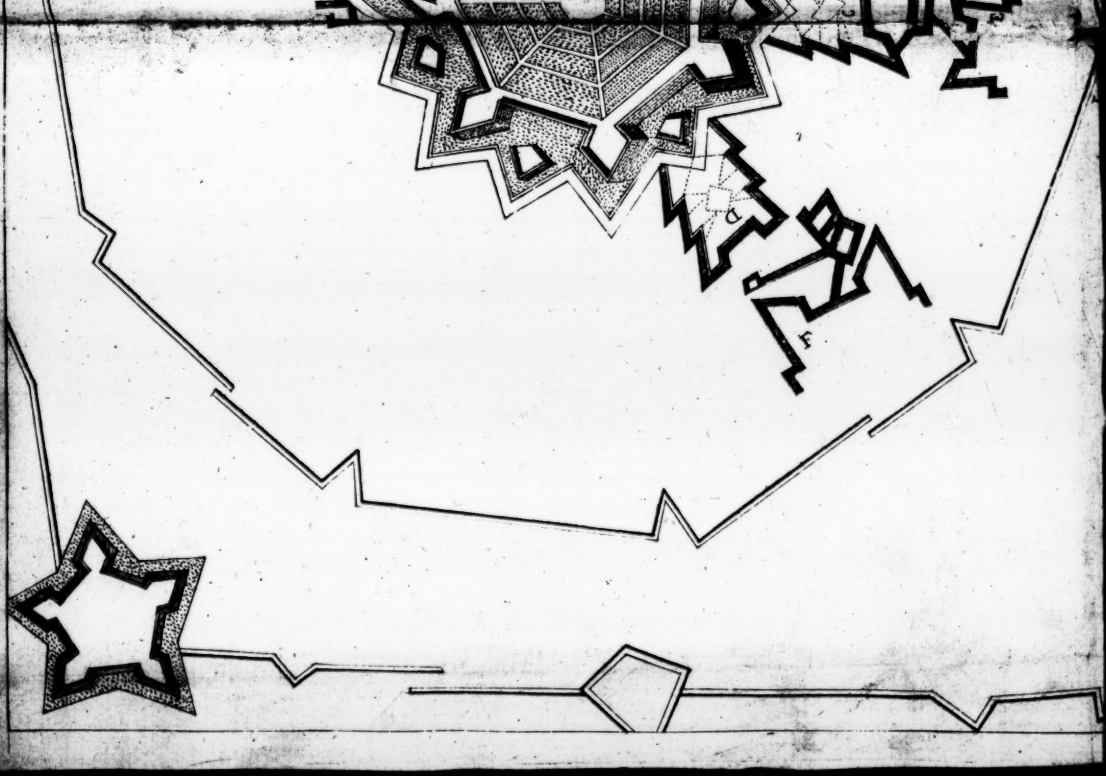


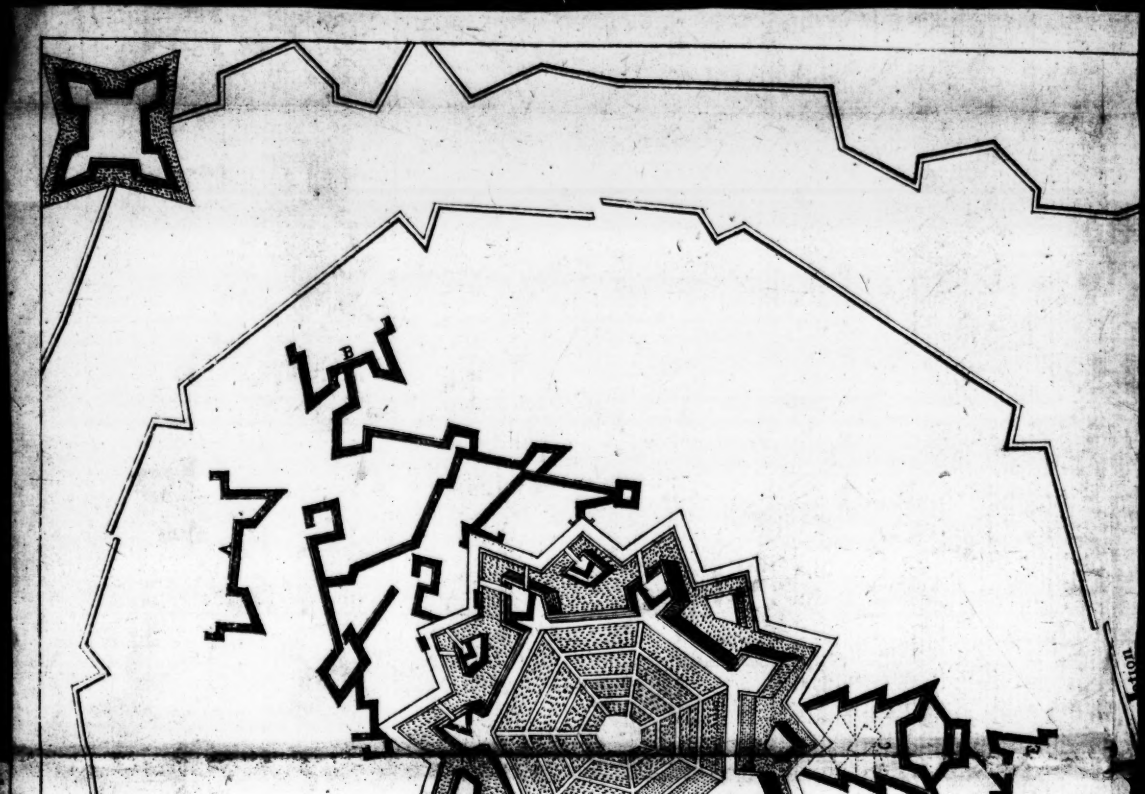


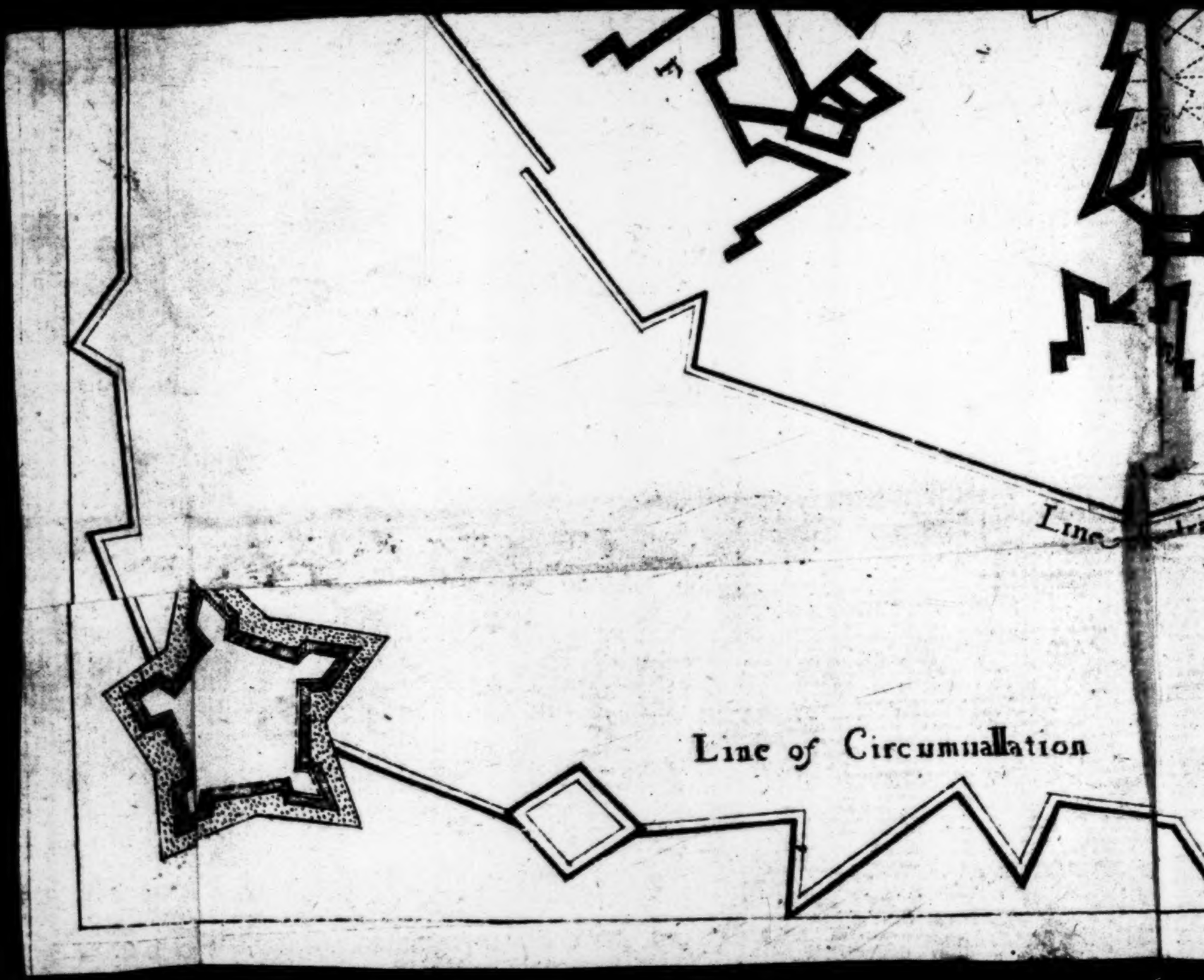


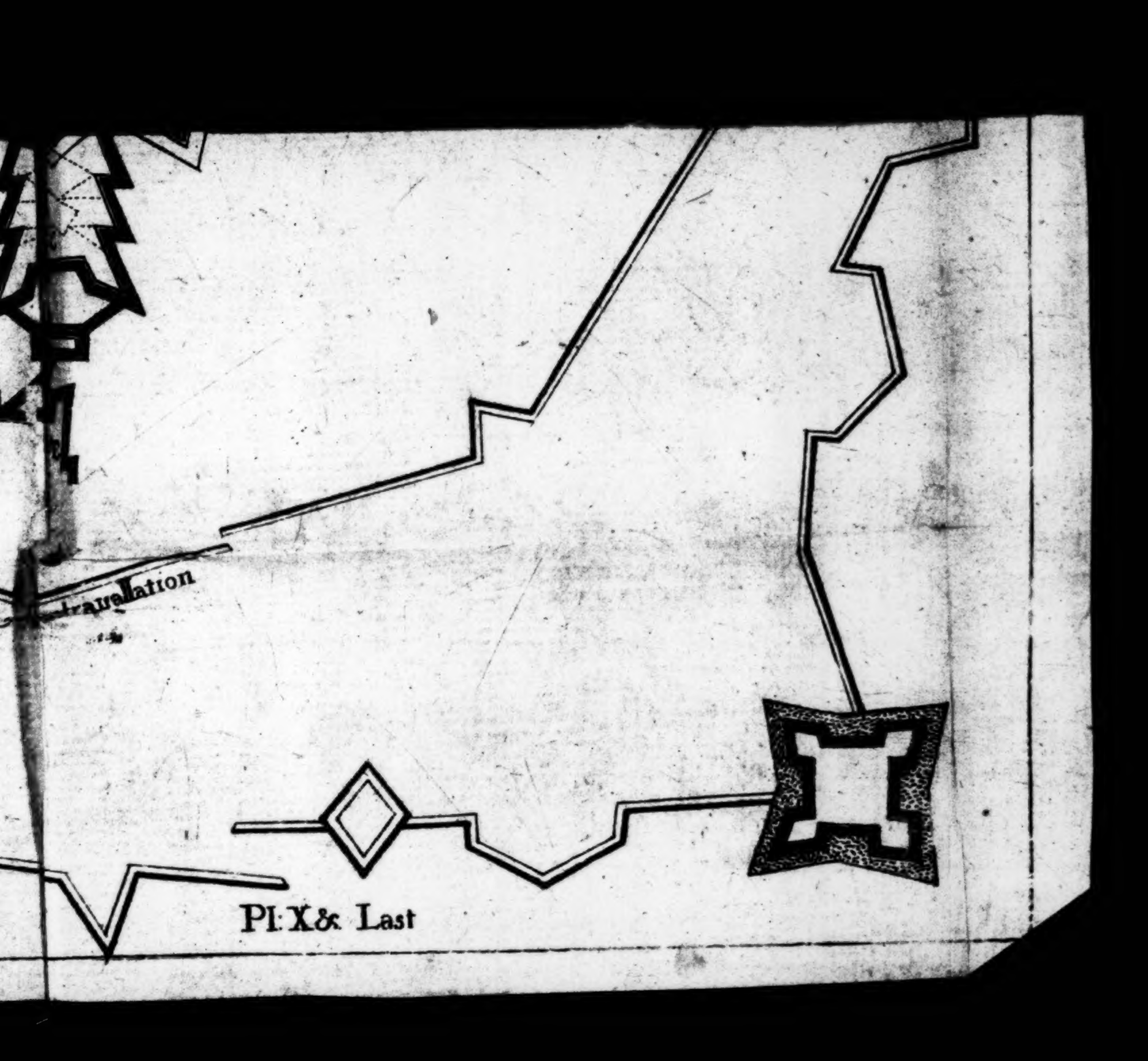


Pl IX


d
f




Line
Line of Circumvallation


travellation
Pl: X& Last